CALIFORNIA ENERGY COMMISSION

TRANSPORTATION FUELS, TECHNOLOGIES AND INFRASTRUCTURE ASSESSMENT REPORT

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CALIFORNIA ENERGY COMMISSION

Charles Mizutani,
Principal Author

Bill Blackburn,
Sue Kateley,
Contributing Authors

Lila Watson,
Project Secretary

Charles Mizutani,
Project Manager

Scott W. Matthews,
Deputy Director
Transportation Energy Division

Karen Griffin,
Program Manager
Integrated Energy Policy Report

Robert L. Therkelsen,
Executive Director

James D. Boyd
Commissioner and Presiding Member
William J. Keese
Chairman and Associate Member
Ad Hoc Integrated Energy Policy Report Committee

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This report was prepared by the California Energy Commission's Ad Hoc Integrated Energy Policy Report Committee to be consistent with the objectives of SB 1389. The report is scheduled for adoption on October 29, 2003. The views and recommendations contained in this document are not the official policy of the Energy Commission until the report is formally adopted.

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Brian Covi
Dan Fong
Chris Kavalec
Tom MacDonald
Daryl Metz
Michael Nyberg
Jim Page
Pat Perez
Jeff Poteet
Gordon Schremp
Leigh Stamets
Peter Ward
McKinley Addy
Gary Yowell

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EXECUTIVE SUMMARY

The inability of today's transportation energy system to fully meet today's needs causes concern about its ability to meet the growing demand for gasoline and diesel in the future. The California Energy Commission and the California Air Resources Board are recommending that the Governor take aggressive steps to safeguard the system against more severe supply disruptions and price volatility. The centerpiece of the agencies' recommendation is that the state should adopt a goal to reduce gasoline and diesel fuel consumption to 15 percent below current levels. This can be achieved largely by doubling the current on-road vehicle fuel economy. The petroleum industry, while supportive of greater vehicle fuel efficiency, has cautioned that significant long-term reductions in demand for petroleum create potential disincentives or barriers to infrastructure investments that must be made in the near-term. Thus, the state must balance supply and price consequences of infrastructure constraints with the potential benefits of increasing vehicle fuel efficiency as a way to moderate growing petroleum dependence.

As California's population and economic output grow, demand for transportation services and fuels will grow. Petroleum will continue to be the energy resource of choice to meet California's transportation energy needs in the near-term. The Energy Commission has forecast that, if left unchecked, total demand for gasoline and diesel fuels will increase by almost 35 percent over the next 20 years. Only incremental increases of in-state refining production can be realized through technological and process improvements. These incremental improvements alone will not be able to keep pace with the rate of future demand growth.

The petroleum industry will need to greatly increase imports of gasoline to meet demand growth. The flow of petroleum fuels into the state can be improved by reducing marine infrastructure bottlenecks. Without further expansion of the marine infrastructure to receive, store and distribute transportation fuels, especially gasoline, supply disruption and price volatility will continue to be an issue for the California public and economy. The length of time and the complexity of acquiring permits to construct facilities is a major impediment to expand marine and storage infrastructure to meet increasing imports. If infrastructure constraints can be alleviated, imported gasoline supply could reach the California market more quickly during a refinery outage, helping to dampen price volatility. Increased private storage could result in more gasoline inventories being available to the market during a supply disruption.

Improved future fuel supply and storage infrastructure can help mitigate current price volatility, but is not sufficient to address continuing transportation fuel demand growth. Increasing imports of gasoline and diesel fuels, well over current levels, will be necessary to meet near-term demand growth, which is expected to increase annual consumption by over 13 percent over the next five years from 18 billion gallons to 20.3 billion gallons.

At this time, there has been a paucity of activity and information to indicate that the transportation fuel industry is planning or can meet California's transportation fuel demand growth. Without increasing the fuel supply by importing additional crude oil and transportation fuels, California will not only continue to experience supply disruptions and price spikes, but also supply shortages and prolonged and elevated prices, for gasoline fuels.

California will experience greater economic and environmental burdens, in the long term, if it continues to rely exclusively on its current transportation energy supplies and does not develop other energy resource options.

Historically, California obtains supplies of crude oil from in-state production, imports from Alaska and imports from foreign sources. Current in-state and Alaskan supplies have peaked and will continue to decline. This has resulted in California's growing reliance on foreign imports to meet its transportation fuel needs.

As the state begins to rely more on imports of crude oil for transportation energy, the status of world oil resources and production rates, along with world demand, becomes increasingly important. Similar to the crude oil resources in Alaska and California, foreign sources of imports will also reach a peak in production before declining.

Experts continue to debate the timeframe in which production of world petroleum resources will peak based on known and available data. Some experts believe the petroleum production peak will occur in the next 10 to 20 years. Other experts and the oil industry in general maintain that technological improvements in extracting petroleum, economics and additional discoveries will extend the production peak well into this century.

The combustion of fossil fuels produces carbon dioxide and other greenhouse gas emissions. The transportation sector accounts for 58 percent of California's carbon dioxide emissions and 49 percent of California's total greenhouse gas emissions. Greenhouse gas emissions from human activities are likely causing changes in the earth's atmosphere, and may have significant economic, environmental, and ecological impacts. As the effects of climate change intensify, transportation fuel options will need to focus on vehicle fuel efficiency improvements and changes to fuels and energy sources with the potential to lower greenhouse gas emissions.

If California is to have, over the long term, a market that provides adequate, secure, and cost-effective transportation fuels, it must simultaneously:

- decrease demand for petroleum fuels by developing more efficient means of using those fuels, and
- begin to transition from petroleum as its predominant source of energy to other sources.

Over the next five to fifteen years, measures that improve vehicle fuel efficiency can lessen the growing demand for transportation fuel. By reducing the rate of transportation fuel demand growth, the need to increase production and importation of gasoline and diesel will be lessened.

In the longer-term, the state needs to transition from its reliance on conventional petroleum resources to a transportation fuel system that uses gasoline and diesel more efficiently along with fuels that have lower life cycle greenhouse gas emissions. The Energy Commission and California Air Resources Board have adopted a policy goal of reducing gasoline and diesel fuel demand to 15 percent below 2003 demand levels by 2020 and to maintain that level for the foreseeable future.

RECOMMENDATIONS

To avoid the adverse consequences of the energy issues confronting California currently, as well as in the longer-term, and be able to provide Californians with adequate, secure and cost-effective transportation fuels, the Energy Commission recommends the following actions be pursued:

1. The Energy Commission should undertake a comprehensive evaluation of California's infrastructure needed to handle future crude oil and petroleum product imports, in consultation with the following agencies – State Lands Commission, Ports of Los Angeles and Long Beach, Coastal Commission, and San Francisco Bay Conservation and Development Commission.

2. The Governor and legislature should identify a state licensing authority for petroleum infrastructure facilities.

3. California should continue to pursue a waiver from U. S. Environmental Protection Agency's gasoline oxygenate requirements.

4. The Energy Commission should continue to monitor the pending federal Energy Policy Act legislation and its impacts on California's transportation fuel price, supply and infrastructure.

5. The Energy Commission should continue to monitor the progress of refineries to meet the California Air Resources Board low sulfur diesel fuel regulation, as well as the progress of other states' implementation efforts.

6. The Energy Commission should continue to work with the petroleum industry to collect information on future expansion and construction plans for in-state refining capacity and importation of crude oil, blend stocks and finished products to assess future supply adequacy, as well as constraints to expansion that might adversely impact future transportation fuel supplies.

7. The Energy Commission should more closely monitor world oil supply markets to provide advance planning to respond to significant changes in world oil production. Areas to monitor include: production profiles, reserves to production ratios, industry and related financial markets, global oil substitution and demand reducing trends,

Organization of the Petroleum Exporting Countries market share trends and crude oil price projections.

8. The Governor and legislature should adopt the recommended statewide goal of reducing demand for on-road gasoline and diesel to 15 percent below the 2003 demand level by 2020 and maintain that level for the foreseeable future.

9. The Governor and legislature should work with the California Congressional delegation and other states and organizations to establish national fuel economy standards that double the fuel efficiency of new cars, light trucks, and sport utility vehicles.

10. The Governor and legislature should establish a goal to increase the use of non-petroleum fuels to 20 percent of on-road fuel consumption by 2020 and 30 percent by 2030.

11. The Energy Commission should establish a working group of industry, environmental, and academic stakeholders to develop specific strategies to support research, development, and demonstration consistent with the recommendations adopted in the ***Reducing California's Petroleum Dependence Report,*** which was in response to the mandates in Assembly Bill 2076 (Chapter 936, Statutes of 2000; Shelley).[1]

12. The Energy Commission should work with the California Air Resources Board to continue to analyze the strategies identified in the Assembly Bill 2076 report to improve its understanding of the costs and effectiveness of new vehicle technologies, the value to the state of reduced environmental damages, and the impact of higher fuel efficiency on vehicle safety, consumer choices, and driving patterns.

13. The Energy Commission should work with the California Department of Transportation to develop and disseminate information on transportation energy issues and evaluate the costs and benefits of fuel demand reduction options and deployment strategies, including: land use planning concepts, public transportation, and voluntary accelerated vehicle retirement.

14. The Energy Commission, working through public/private collaborations and partnerships, should pursue basic transportation energy research, hardware development, and infrastructure deployment.

CHAPTER 1: INTRODUCTION

Recommending energy policy for the State of California is the basis for the development of the ***Integrated Energy Policy Report***. Senate Bill 1389 (Chapter 568, Statutes of 2000; Bowen) requires the California Energy Commission (Energy Commission) to identify emerging energy trends, potential adverse social, economic and environmental impacts, and assess and recommend administrative and legislative actions for the transportation, electricity and natural gas energy sectors. This report addresses the trends and issues and makes recommendations for fuel use in the transportation sector.

Mobility is a public good that provides economic benefits to California. The ability to move people, goods and services efficiently and cheaply has been able to support the state's competitiveness as the fifth largest economy in the world. Industry and the public sector have developed technologies, infrastructure and fuels to meet Californians' transportation needs. A critical component of mobility has been the availability of those fuels used to move the vehicles that transport goods and people. Mobility, while providing economic benefits, has also created resource challenges in the form of dependence on a finite resource, petroleum, and environmental damages in the form of air, water and waste pollution. While ensuring adequate and reliable transportation energy to Californians is a primary energy goal, state action to protect public health and the environment remain important objectives that need to be considered in developing energy policies.

Public Resources Code (PRC) Section 25304 directs the Energy Commission to conduct transportation forecasting and assessment activities, including:

1. Transportation fuels, technologies and infrastructure trends.

2. Transportation energy demand forecast.

3. Sufficiency of transportation fuel supplies.

4. Risks of supply disruptions, price shocks or other events and their consequences on transportation fuels and the state's economy.

5. Potential for needed changes to maintain sufficient, secure and affordable transportation supplies.

6. Alternative transportation energy scenarios to examine potential effects on public health and safety, the economy, resources, the environment and energy security.

7. Status of advanced transportation technologies and clean-burning transportation fuels.

8. Recommended actions to improve efficiency of transportation energy use, reduce petroleum fuels dependence, decrease environmental impacts, contribute to reducing

congestion, promoting economic development, enhancing energy diversity and security, and advance public interest energy strategies for transportation.

The ***Transportation Fuels, Technologies, and Infrastructure Assessments Report*** provides the information and analysis for the forecasting and assessment activities identified under PRC Section 25304, as part of the Senate Bill 1389 energy policy requirements for the Energy Commission. The report is organized to follow the sequence of forecasting transportation energy demand; evaluating the sufficiency of transportation energy supplies; identifying issues and barriers that prevent supply and demand balance; assessing the issues and barriers; and developing findings and recommendations to overcome or mitigate the issues and barriers.

A general summary of the remaining individual chapters follows.

Chapter 2: Twenty-year forecasts of transportation fuels are developed and the factors that most affect continued growth of energy demand for transportation fuels are identified.

Chapter 3: Future supply trends based on current production capability are developed and California's fuel supply status is presented.

Chapter 4: Issue areas that create and exacerbate the growing supply and demand imbalance are identified and discussed.

Chapter 5: Analysis, findings and conclusions are developed to mitigate current and future price shocks.

Chapter 6: Analysis, findings and conclusions are developed to address the current issue of gasoline and diesel supply sufficiency.

Chapter 7: Analysis, findings and conclusions are developed to address the issue of growing reliance on imported petroleum by developing and implementing a portfolio of energy efficiency and non-petroleum fuel options to displace petroleum fuels.

Chapter 8: Recommended options to improve California's transportation energy system are identified.

CHAPTER 2: TRANSPORTATION ENERGY DEMAND

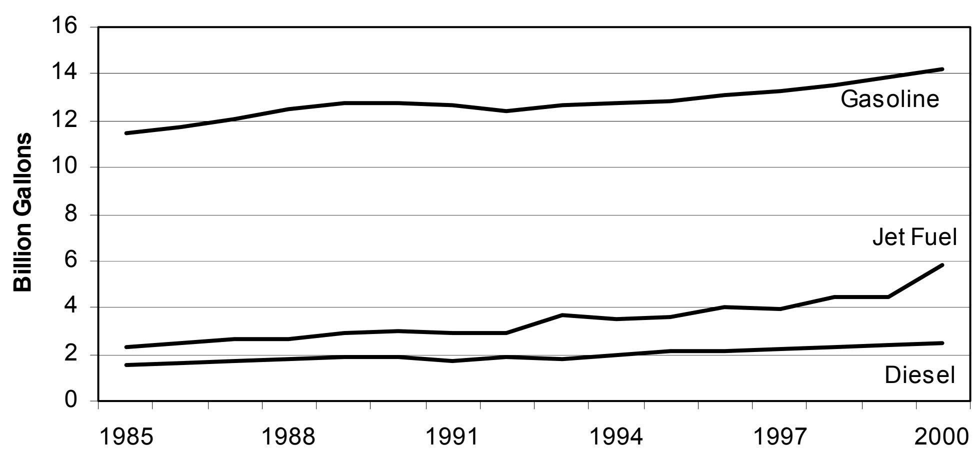
California's demand for mobility and transportation fuels continues to increase as its population and economy grow. Motor vehicles will continue to be the most economical and convenient mode to transport goods, services and people for the foreseeable future.

CURRENT TRENDS

Beginning in the 1980s, California's population grew an average of 1.9 percent per year and the number of on-road vehicles grew at nearly the same rate. Due in part to rising, real per-capita income and longer home to work distances, total on-road travel in the state increased at a significantly higher rate—an average of 3.3 percent annually. During the same period, gasoline and diesel demand increased by an average of 1.8 percent.

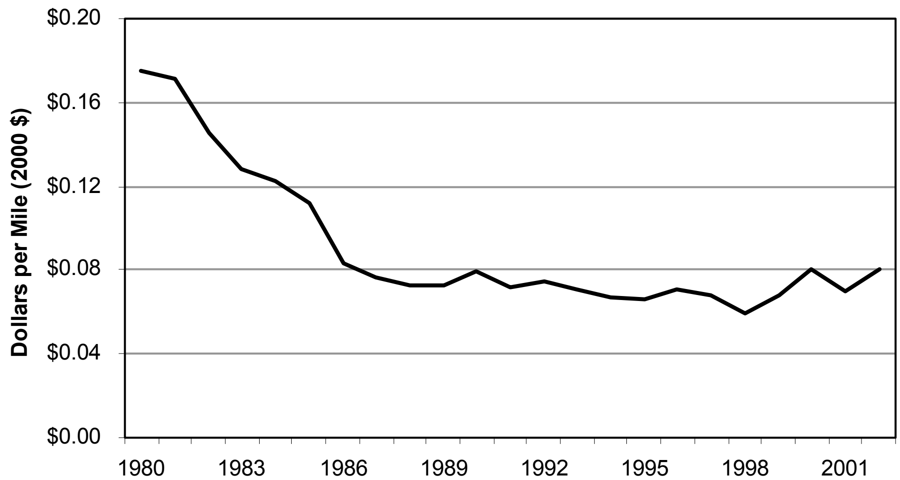
Figure 2-1 shows historical gasoline, diesel and jet fuel demand in California. The decline in petroleum demand during the late 1980s and early 1990s and the resumption of demand growth in the middle 1990s are indicative of the way economic activity affects transportation demand; these patterns closely follow California's economic conditions in the post Cold War era.

Figure 2-1
Historical California Demand for Gasoline, Diesel and Jet Fuel



Travel increased at almost twice the rate of population growth. Since 1980, the real cost of gasoline has dropped by 40 percent while fleet-average fuel economy has nearly doubled.[2] As a result, the average per-mile cost of gasoline is less than one-half of what it was in 1980. **Figure 2-2** shows the average per mile cost (in 2000 dollars) of operating a gasoline-powered light-duty vehicle (LDV) over the period from 1980 to 2002.

Figure 2-2
Average per Mile Cost of Gasoline, 1980-2002



For 2002, the average California household vehicle miles traveled (VMT) was 20,049 miles. Per household, gasoline purchases averaged 954 gallons in 2002. For the same period, VMT per business establishment averaged 66,929 miles. Per business establishment gasoline purchases averaged 3,220 gallons and diesel purchases averaged 2,419 gallons. During this period the price for gasoline and diesel averaged $1.47 and $1.48 per gallon respectively. Out-of-pocket gasoline cost per household was $1,400 per year and business was $8,300 per year.[3] Annual fuel costs are, on average, substantially lower than in 1980 for both private households and business establishments due to improved fuel efficiency and declining real fuel prices.

In **Table 2-1**, gasoline demand exceeds all other types of fuel demand.[4] Gasoline demand is more than three times greater than jet fuel. In the transportation sector, distillate, primarily diesel, is used for on-road vehicles, railroads and marine vessels. On-road vehicles use about 90 percent, and railroad applications use another eight percent of the distillate consumed for transportation in California.[5] In comparison with other sectors, transportation distillate use is nearly four times the combined distillate use for on-farm and off-highway applications, primarily construction.

LDVs account for nearly all of California's on-road passenger movement. LDVs include automobiles, pickup trucks, vans, and sport utility vehicles (SUVs). The latter three vehicle categories are termed "light truck," and collectively comprise 41 percent of LDVs. In 2002, Californians registered about 24 million gasoline-powered vehicles. Alternative fuel vehicles - liquefied petroleum gas, natural gas, and electric vehicles, cumulatively totaling about 80,000 (or approximately three-tenths of one percent of the vehicle population), also operate in California. In 2001, Californians purchased 1,078,000 new cars and 971,000 new light trucks. Commercial fleet vehicles account for about one-third of these purchases.

Table 2-1
California Petroleum Demand in the Transportation Sector—2000

Fuel Type	Percent	Thousand Barrels per Day
Motor Gasoline	61.1%	933
Jet Fuel	18.4%	282
Distillate	12.5%	191
Residual	7.3%	112
Other	0.7%	11
Total	100.0%	1,529

The federal Corporate Average Fuel Economy (CAFE) Program was enacted into law by Congress in 1975 and implemented in 1978 with a goal of doubling the 1974 new passenger car fleet fuel economy to 27.5 miles per gallon (mpg) by 1985. In 1985, the U.S. fleet of new passenger cars achieved a 27.6 mpg average. Since that year, neither Congress nor the National Highway Traffic Safety Administration (NHTSA), the agency responsible for administering the CAFE Program, has acted to increase the standard.

Congress implemented a new light truck fuel economy standard in 1979 based on technical and economic feasibility rather than the "doubling the fuel economy" goal chosen for passenger cars. NHTSA was given the authority to set light truck fuel economy standards for each model year. The light truck standard applicable to two-wheel drive light trucks, minivans and SUVs has been 20.7 mpg. In 2003, NHTSA promulgated light truck CAFE standards for model years 2005, 2006 and 2007, which are 21.0, 21.6 and 22.2 mpg, respectively.

The average fuel economy of on-road gasoline-powered LDVs in California increased since the mid-seventies from 12.6 mpg to today's 20.6 mpg. However, consumers' growing preference for light trucks, particularly minivans and SUVs with lower average fuel economy, has caused on-road fleet-average fuel economy to level off for the first time since 1973.

Heavy-duty vehicles (HDVs) include medium and heavy-duty trucks and buses. Most HDVs provide on-road freight movement. A much smaller number account for passenger transport. There are about 867,000 HDVs registered in California (HDVs are generally defined as those vehicles that weigh over 10,000 pounds), which use approximately 2.6 billion gallons of diesel and 0.7 billion gallons of gasoline annually.

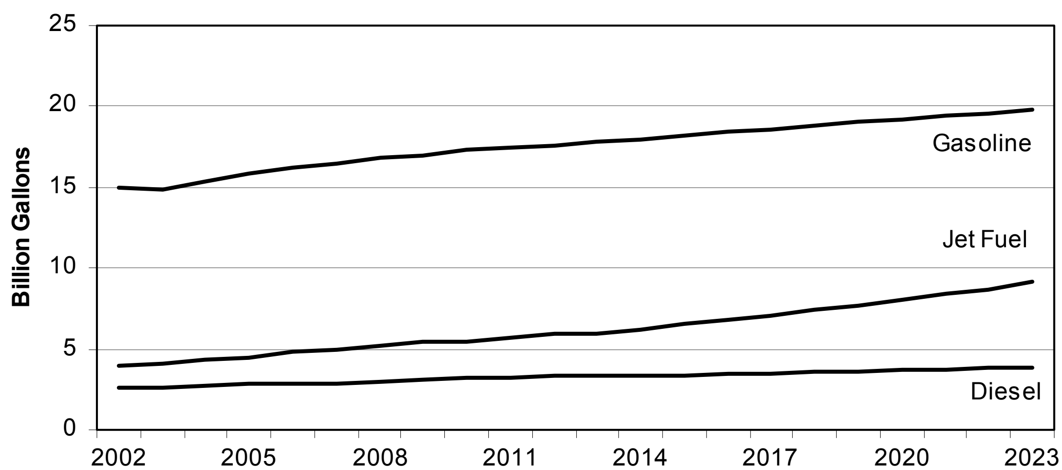
FORECAST

Figure 2-3 shows the Energy Commission's base-case forecast for on-road gasoline, on-road diesel, and jet fuel demand. The forecast projects on-road gasoline demand to increase from

15.0 billion gallons in 2002 to 17.3 billion gallons in 2010 and to 19.8 billion gallons by 2023. Jet fuel demand is projected to increase from 3.3 billion gallons in 2002 to 4.6 billion gallons in 2010 and to 7.4 billion gallons by 2023. Diesel demand is projected to increase from 2.7 billion gallons in 2002 to 3.3 billion gallons in 2010 and to 4.0 billion gallons by 2023. These forecasts translate to an average increase of about 1.4 percent per year for gasoline, 4.0 percent annually for jet fuel and about 1.9 percent for diesel.

The forecast of jet fuel demand is based on projecting growth of commercial aviation passenger volume in California from 159 million in 2000 to 366 million in 2023. Although commercial aviation travel in California declined about 10 percent between 2000 and 2002, airline travel is assumed to resume its historical growth rates beginning in 2003.[6] Base-case projections for electricity and compressed natural gas (CNG) demand include transit as well as light-duty applications.

Figure 2-3
California Demand for Gasoline, Diesel and Jet Fuel Forecast

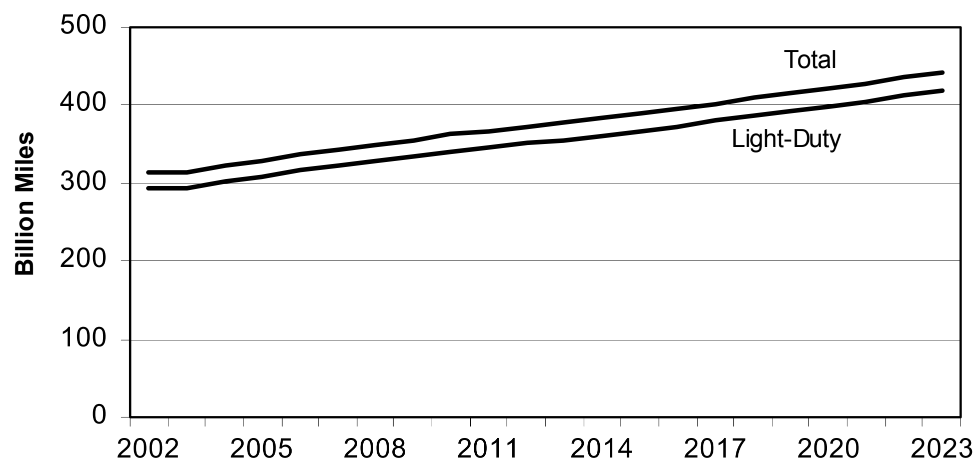


By 2023, the Energy Commission projects that the number of on-road vehicles will reach over 33 million in California, up from about 24.4 million in 2002 (of which over 97 percent are LDVs),with an average growth rate of 1.5 percent per year. Primarily due to the continued growth in the smaller sport and cross utility vehicles, the forecast projects that light trucks will continue to increase as a percentage of LDV stock in California, making up over 44 percent by 2023, up from 41 percent in 2002. The base case assumes slight fuel economy growth in conventional gasoline vehicles after 2008, significant penetration levels projected for electric hybrids, and increased availability of light-duty diesels. These assumptions yield a forecast that shows LDV fleet-average fuel economy increasing by 2.4 percent over the forecast period, from 20.6 mpg in 2002 to 21.1 mpg in 2020. Fuel efficiency for gasoline LDVs is projected to decline slightly until model year 2007 or 2008, reflecting recent trends, and then begin to increase. As an example, compact car mpg declines from 26.0 to 25.9 between 2003 and 2008, and then reaches 26.3 mpg by 2020.

The Energy Commission's base-case forecast assumes gasoline prices of $1.68 per gallon (in 2003 dollars) beginning in 2004. The price for on-road diesel is projected to be $1.63 in 2004 and 2005, and $1.67 from 2006 onward. These projections are based on long-term world crude oil prices averaging $25.00 per barrel.[7] In addition, the Energy Commission assumes that smaller sport and cross utility vehicles will continue to increase as a percentage of new LDV sales through 2010.

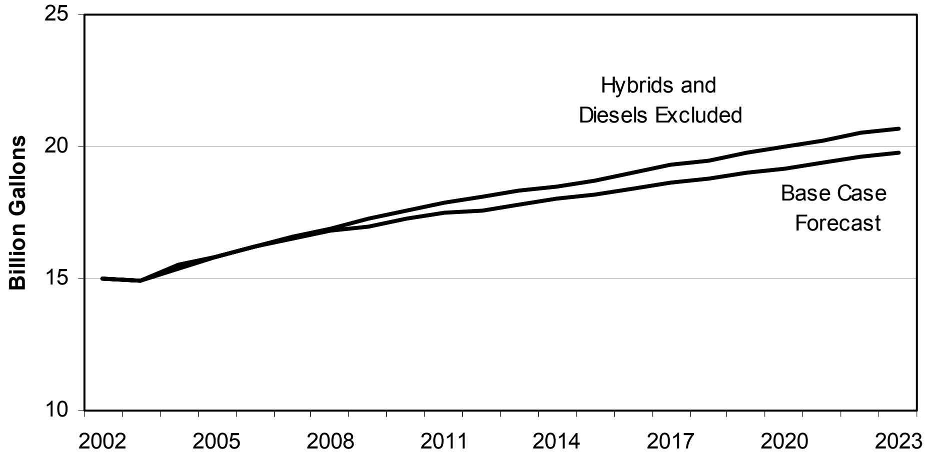
Figure 2-4 shows the projected trend in VMT for LDVs and all uses combined. The Energy Commission projects that on-road VMT (LDVs, freight, and transit) will increase in California from 313 billion miles in 2002 to 362 billion miles in 2010 to over 440 billion by 2023. This represents an average increase of 1.7 percent per year over the forecast period. Light-duty vehicle VMT, which makes up about 95 percent of the total, is expected to increase from 294 to almost 420 billion miles over the forecast period, a rate of 1.7 percent per year.

Figure 2-4
Forecast On-road Vehicle Miles Traveled 2003-2023



Electric hybrid vehicles sales are projected to increase from 5,300 in 2002 to 144,000 in 2010 and to 259,000 by 2020 (about nine percent of total sales in 2020). For light-duty diesels, sales are projected to reach 56,000 in 2010 and 70,000 by 2023. The fleet penetration of hybrids and diesels serves to reduce LDV gasoline demand projections by almost one billion gallons per year by the end of the forecast period as shown in **Figure 2-5**. Without increased market penetration of hybrids and light-duty diesels, the projected growth rate for gasoline demand from 2003-2023 would average 1.6 percent per year.

Figure 2-5
Impact of Hybrid and Diesel Vehicles on Projected Demand



Demand for electricity in the transportation sector is expected to grow from 660 to 2,000 million kilowatt-hours between 2002 and 2023. During the same period, demand for natural gas in on-road vehicles will increase from 62 to 250 million therms. Transit accounts for much of the electricity and natural gas demand. **Table 2-2** presents estimates of annual energy use for transit.

Table 2-2
Transit Energy Use

	2002	2023
Electricity (million kWh)	630	2000
Natural Gas (million therms)	40	100
Diesel (million gallons)	100	130
Gasoline (million gallons)	40	40

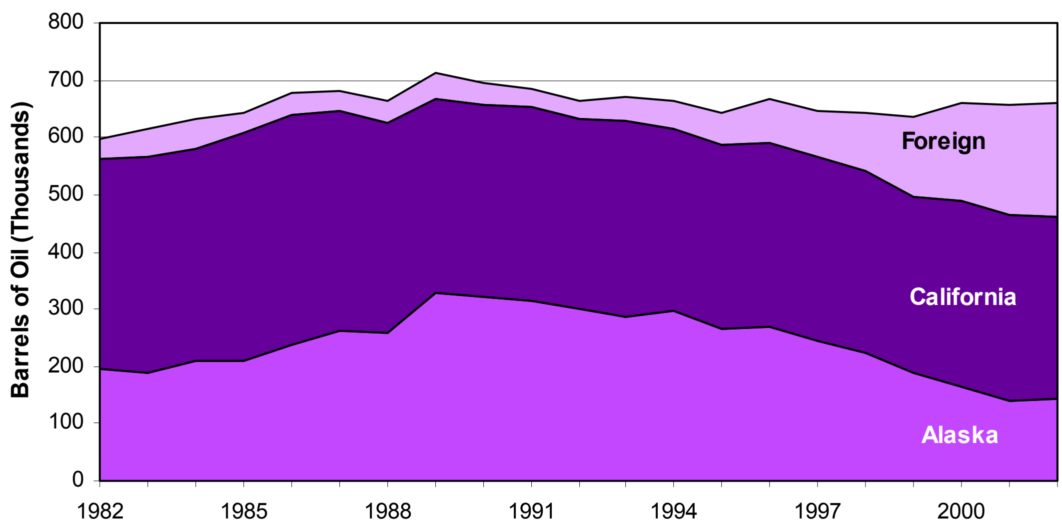
CHAPTER 3: TRANSPORTATION ENERGY SUPPLY

California's transportation fuel supply industry has evolved from primarily being able to provide fuels from in-state refining to an industry that is increasingly having to import crude oil and finished products from foreign sources.

SOURCES OF PETROLEUM FOR CALIFORNIA REFINERIES

Californians currently consume approximately 42 million gallons of gasoline and over 7.5 million gallons of diesel per day. According to the Energy Commission forecast, that consumption will grow to 55 million gallons of gasoline and nearly nine million gallons of diesel per day by 2023 assuming current trends continue. California imports gasoline and blend stocks to meet demand. California also imports jet fuel, diesel, crude oil and ethanol. Approximately 11 percent of California's gasoline production is exported to Nevada and Arizona to meet their transportation fuel needs. California acquires crude oil from within California and imports the rest from Alaska and foreign sources. As shown in **Figure 3-1,** in recent years, supplies of crude oil from within California (48 percent in 2002) and from Alaska (22 percent in 2002) have been declining, requiring California to import an increasing proportion of its crude oil from foreign sources (30 percent in 2002).[8]

Figure 3-1
Oil Supply Sources to California Refineries

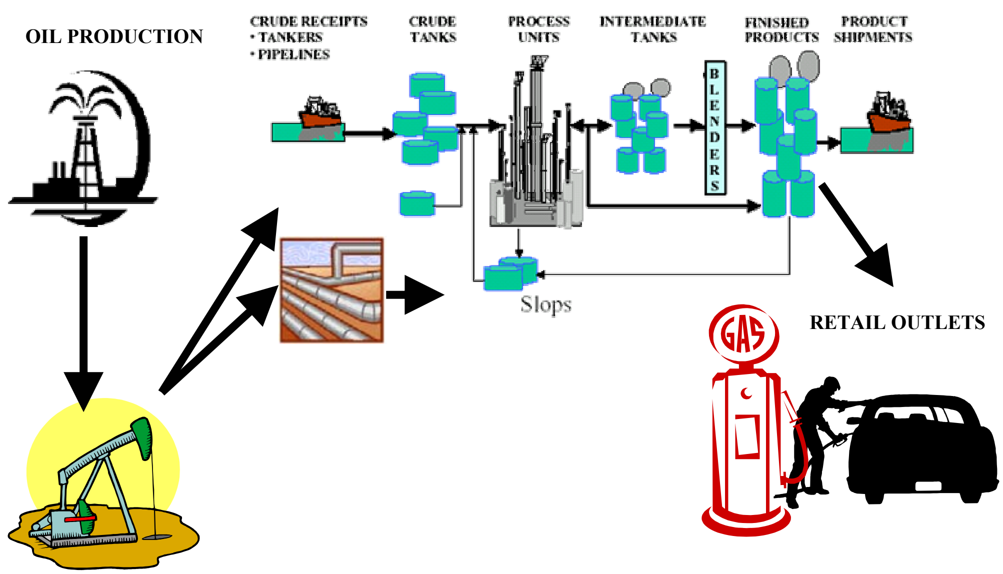


CURRENT SUPPLY

California's supply of transportation fuel involves the importation of crude oil and unfinished product components which are refined into finished product, as well as the importation of finished product. Imports, i.e., crude oil, unfinished and finished products, arrive via marine, and rail delivery systems.

As shown in **Figure 3-2**, California's petroleum infrastructure consists of refineries, terminals (some of which are marine facilities), distribution terminals, and storage facilities. Pipelines connect the refineries, to the marine docks and tanks, and to the inland distribution terminals. From the oil well the product flows through a variety of delivery mechanisms, including tankers and pipelines. Crude oil is stored in large tanks until it is needed at the processing units. Other products needed to manufacture transportation fuels are delivered by rail and/or pipeline to the processing units and then transferred to intermediate tanks to await final processing. Blending components are added and the fuels are stored in tanks until needed by the retail stores that sell fuels. Products sold to other regions of the U.S. are moved via barges, tankers or pipelines to their final destination.

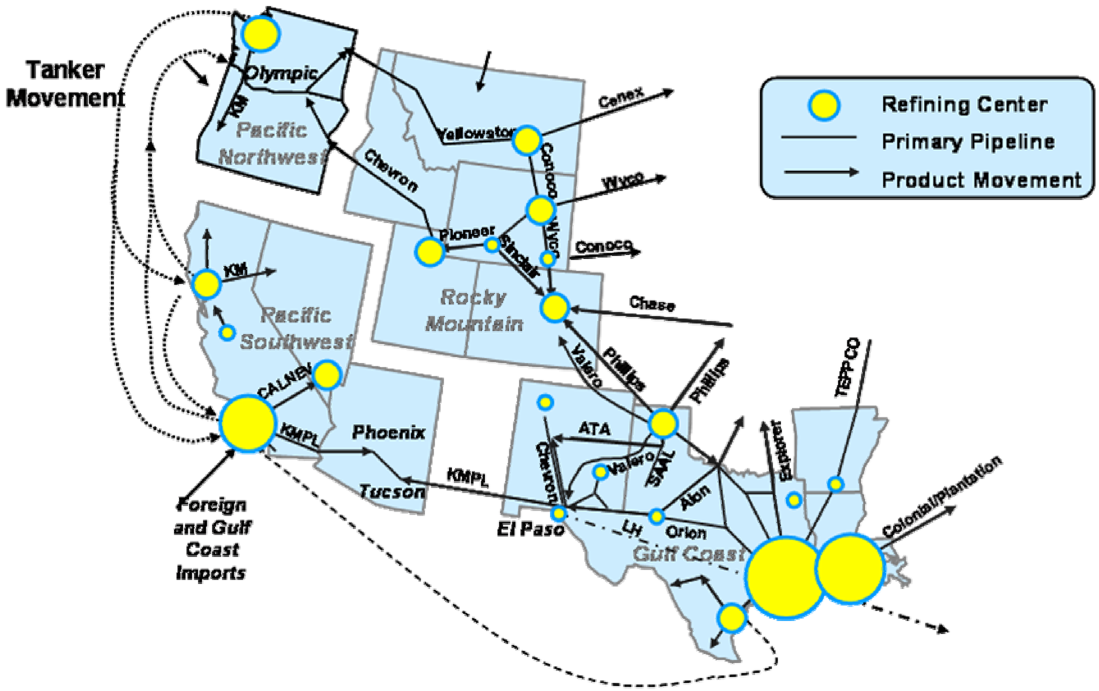
Figure 3-2
From Well to Wheels



Transportation Fuel Supply Sources

Figure 3-3 shows how crude oil, finished and unfinished products are supplied to California and other regions of the U.S.[9] These products move from refining centers throughout the U.S. to and from California via a network of pipelines, tankers and barges.

Figure 3-3
Western Supply Network



Crude Oil Imports and Outlook

California refiners obtain crude oil from in-state production, Alaska and foreign sources. Waterborne receipts of crude oil for 2001 amounted to an average of 425 thousand barrels per day for the San Francisco Bay Area and over 520 thousand barrels per day for the Ports of Los Angeles and Long Beach. Both California and Alaska crude oil production continue to decline, while the nearly two million barrels per day of crude oil used by California's refineries is forecast to increase slightly, by less than one percent per year. Refiners are therefore expected to increase their imports of crude oil from foreign sources. These additional imports will be brought to the state in marine tankers.

Current capacity to receive crude oil is sufficient for both Northern and Southern California. The outlook for the next several years is that Very Large Crude Carrier (transporting one to two million barrels) use will need to double from an average of one to two ships per week due to greater reliance on foreign sources of crude oil. For this reason, additional infrastructure improvements for berthing facilities as well as crude oil storage tanks will need to be constructed. This should not create a major problem if industry can undertake the work within the next five to ten years. However, this outlook assumes that existing infrastructure assets for receiving crude oil are not diminished over the next several years by new operational restrictions imposed by port authorities or other governing bodies.

Refineries

California has two distinct refining centers in Northern and Southern California. Since there are no pipelines connecting these two primary refining centers, petroleum products are moved between them by coast barges, adding to marine infrastructure requirements.

As listed in **Table 3-1,** California has 21 in-state refineries located in or near two refining centers. Not all of these refineries produce gasoline.[10] Fifty-nine percent of the fuel products made by these refiners is gasoline for the California market. The remainder is jet fuel, distillates, residual fuels and gasoline for markets outside California.

Since 1996, California petroleum production capacity has grown less than consumer demand. There has been some slow growth in California refining capacity since 1996 - about 1.5 percent per year on average. During major turnarounds, refiners can sometimes expand refinery capacity marginally through maintenance upgrades. Total in-state refinery production capacity is approximately two million barrels per day (calendar-day capacity). Most of the time, all of the state's refineries are operating between 85 and 100 percent of capacity.[11]

Product Tankers, Berths and Moorings

Tankers are an important source of supplies to bring petroleum products to California. The average volume a vessel carries is 275,000 barrels. Ships from the U.S. Gulf Coast travel to California via the Panama Canal to either Los Angeles or San Francisco. Typical one-way trip times are 21 to 23 days. Fleets loaded at a U.S. port that sail to another U.S. destination must be shipped on a domestic flag vessel in accordance with federal law (Jones Act). There are currently 64 vessels that meet this requirement. Some of these ships will be retired between 2001 and 2015 under the provisions of the federal Oil Pollution Act of 1990. New tankers that meet the provisions of the federal Oil Pollution Act of 1990, foreign tankers, or barges will have to be deployed or reassigned to deliver product.[12]

In the San Francisco Bay Area, the marine petroleum infrastructure is concentrated in the northeastern parts of the Bay, in Richmond, in San Pablo Bay and in the Carquinez Strait. Cargo deliveries are limited by the depth of the Bay, which restricts the size and load of the vessels moving through the Bay, particularly near the Pinole Shoals.

In the Los Angeles area, many refineries and terminals that are part of the marine petroleum infrastructure in the Los Angeles Basin are actually located up to ten miles or more inland and connected to the dock by pipelines. Expansion of terminals for handling containers from cargo ships has reduced the amount of space available for marine tankage.

Table 3-1
California In-State Refinery Product Capacities by Location

NAME & LOCATION	CRUDE OIL CAPACITY (Barrels Per Day)	MAJOR PRODUCTS
NORTHERN REFINERIES		
ChevronTexaco – Richmond	225,000	Gasoline, Diesel, Jet Fuel, Residual Fuel
Kern Oil – Bakersfield	24,700	Gasoline, Diesel, Asphalt
San Joaquin – Bakersfield	24,300	Diesel, Residual Fuel, Asphalt
Shell – Bakersfield	66,000	Gasoline, Diesel, Residual Fuel
Shell – Martinez	159,250	Gasoline, Diesel, Jet Fuel, Residual Fuel
Tesoro – Concord	166,000	Gasoline, Diesel, Residual Fuel
Valero (formerly Exxon) – Benicia	129,500	Gasoline, Diesel, Jet Fuel, Residual Fuel
Valero (formerly Huntway) – Benicia	14,500	Asphalt
SOUTHERN REFINERIES		
BP (formerly ARCO) – Carson	260,000	Gasoline, Diesel, Jet Fuel, Residual Fuel
ChevronTexaco – El Segundo	260,000	Gasoline, Diesel, Jet Fuel, Residual Fuel
Conoco Phillips – Rodeo	73,200	Gasoline, Diesel, Jet Fuel, Residual Fuel
Conoco Phillips – Wilmington	136,600	Gasoline, Diesel, Jet Fuel, Residual Fuel
Edgington – Long Beach	26,000	Diesel, Asphalt
Exxon/Mobil – Torrance	149,000	Gasoline, Diesel, Jet Fuel
Lunday Thagard – South Gate	8,100	Asphalt
Paramount – Paramount	50,000	Gasoline, Jet Fuel, Residual Fuel, Asphalt, Blendstocks
Santa Maria	9,950	Asphalt
Shell – Wilmington	98,500	Gasoline, Diesel, Jet Fuel, Residual Fuel
Tenby Inc.- Oxnard	2,800	Asphalt
Valero – Wilmington	5,770	Asphalt
Valero (formerly Ultramar) – Wilmington	80,887	Gasoline, Diesel, Jet Fuel, Residual Fuel
TOTAL IN-STATE REFINERY PRODUCT CAPACITY	**1,970,057**	

Terminals (Marine, Distribution and Storage Facilities)

In Northern California, there are storage terminals located within several refineries and marine terminals. There is roughly 55 million barrels of storage capacity in Northern

California refineries and terminals. Southern California refineries and terminals have roughly 61 million barrels of storage capacity. There is an estimated volume of 1.4 million barrels of capacity additions that are in various stages of planning and construction in California. Increased private storage could result in more gasoline inventories available to the market during a supply disruption.

However, all of these storage projects have been undertaken with the use of existing permits. Future projects to construct additional storage tanks could require extensive environmental assessment and a lengthy approval process. The state's petroleum product infrastructure may be inadequate even with these new projects and the permitting process may unduly burden applicants and agencies and inhibit the deployment of infrastructure needed to support demand.

Petroleum Product Pipelines

The Southwestern United States (California, Nevada and Arizona) contains a number of petroleum product pipelines. The largest system is owned by Kinder Morgan, "common carrier" company, consisting of over 3,400 miles of pipeline (a "common carrier" company does not own the products shipped via its pipelines). The largest common carrier system transports refinery products to Nevada and Arizona. The same common carrier operates a pipeline system that moves product within California. There are no pipelines that bring product to California. There were projects proposed for construction that could provide additional shipping capacity to the Southwest, however, some of those projects may no longer be actively under consideration. Supply lines to Southwestern states (California, Nevada and Arizona in particular) are important to having adequate fuel delivery infrastructure. The availability of supplies to the Southwestern states may relieve some of the need for California's refineries to export product outside of California and free up some product for in-state supply.

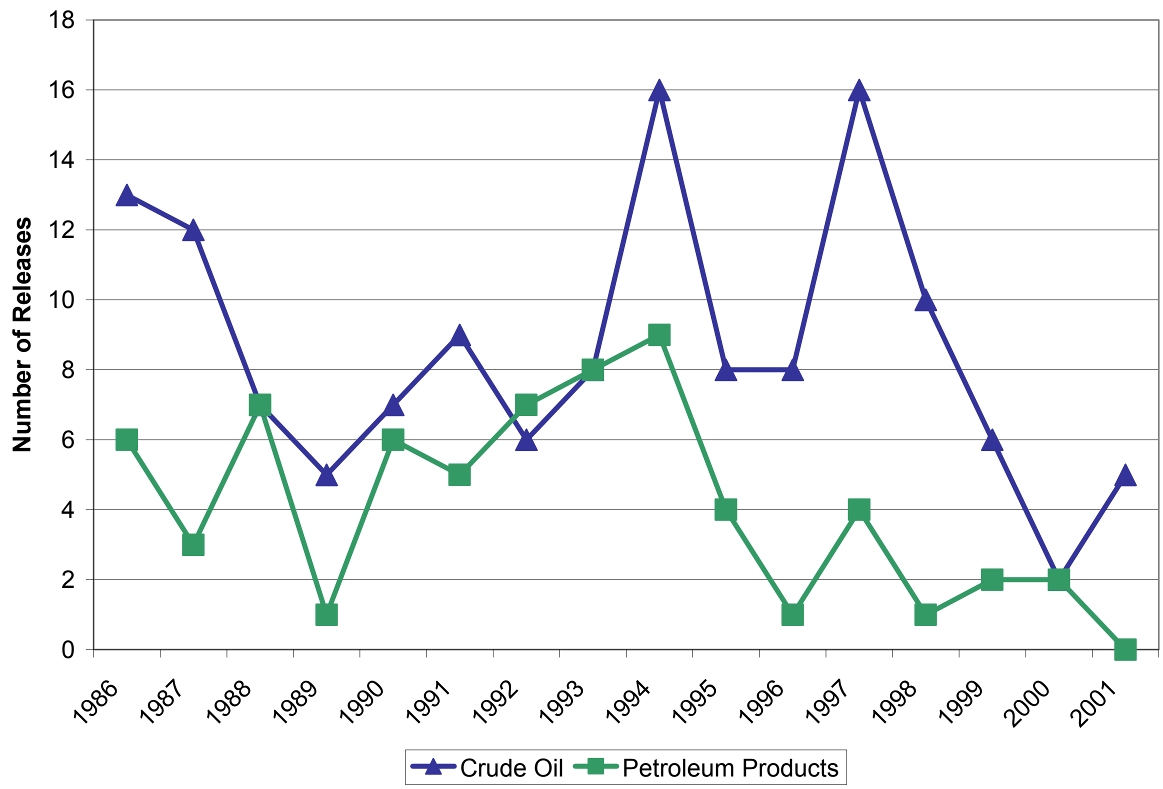
Petroleum Pipeline Infrastructure

Transportation fuels produced at refineries and imported to California are primarily distributed to over 60 terminals located throughout the state via a network of petroleum product pipelines. The petroleum product pipelines in Northern California connect the Bay Area refineries to terminals located in Sacramento, Chico, Reno, Stockton, Fresno, San Jose, Oakland and the San Francisco Airport. There is no pipeline that connects Northern California with Southern California. Refineries located in Southern California are connected to terminals in Los Angeles, San Diego, Imperial, Barstow, Las Vegas, Phoenix and Tucson. In addition to the pipelines that connect refineries to terminals, there is also a network of pipelines that connect the marine facilities that receive imports to refineries and other storage terminals. During the peak period of gasoline demand (summer months), some of these pipeline segments reach maximum capacity which results in distribution constraints. Even if additional imports can be discharged from marine vessels without undue delays, the ability to continue the distribution of these refined products to their ultimate destinations could face a growing barrier of ever-increasing pipeline infrastructure constraint.

Petroleum Pipeline Reliability

On occasion petroleum pipelines are temporarily shut down for maintenance or in response to a leak as was the recent case with the temporary closure of the Kinder Morgan Pipeline between Tucson and Phoenix, Arizona. As shown in **Figure 3-3**, since 1986, incidents involving a release of crude oil or refined products from pipelines located in California have generally declined. A release is when the flow in a pipeline carrying crude oil or refined products is compromised and its contents are released to the surroundings. The number of petroleum product releases peaked in 1994 when there were nine incidents that resulted in a release of six barrels or more of refined product. Since that peak, the number of incidents per year has declined. Over the entire period, 1986 through 2001, there has been an average of 4.1 incidents per year. The number of releases involving crude oil pipelines averaged 8.6 incidents over the same time period. Incidents involving crude oil releases peaked in 1994 and again in 1997 at 16. Like petroleum products, the number of incidents over the last few years involving crude oil pipelines has been quite low.

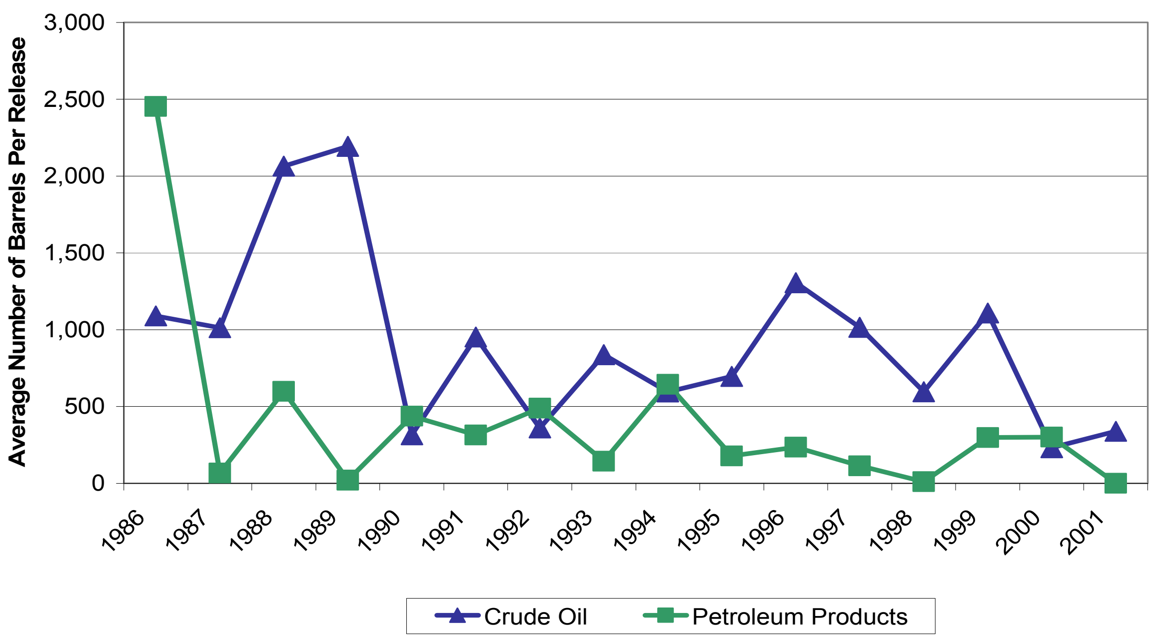
Figure 3-3
CALIFORNIA PIPELINE RELEASES
1986 THROUGH 2001



The declining rate of pipeline incidents in California has also been associated with a decrease in the average amount of crude oil or petroleum products released per incident. As shown in **Figure 3-4**, between 1986 and 2001, nearly 128 thousand total barrels of crude oil was released as a result of 138 incidents accounting for an average quantity of 927 barrels per incident. Over the same time period, about 36 thousand barrels of petroleum products was released during 66 incidents accounting for an average quantity of 550 barrels per incident.

To put these releases in perspective, California refiners have processed an average of about 1.6 million barrels per day of crude oil, all of which was transported at some point through crude oil pipelines. The average distribution of refined petroleum products was similar. The releases of crude oil and petroleum products from pipeline systems located in California have been remarkably low, less than 0.06 percent for crude oil and a little over 0.03 percent for refined products.

Figure 3-4
CALIFORNIA PIPELINE RELEASES
AVERAGE QUANTITY PER INCIDENT
1986 THROUGH 2001



Interruption of pipeline service occurs with less frequency than that of refinery operations. Temporary closure of a pipeline segment usually has a lesser impact on supply because shippers can find alternative means of delivery (more tanker trucks) within days, not weeks. In addition, pipeline incidents can normally be repaired in a couple of days whereas refinery outages may take a week or more to correct and restore to normal output.

On rare occasions, a pipeline incident can have a significant impact on fuel supplies. This was the case with the recent temporary closure of a pipeline between Tucson and Phoenix, Arizona. It is unlikely that an individual pipeline outage in California could result in the same consequences because no single pipeline segment accounts for a large amount of California’s fuel supply. But an extended loss of certain pipeline segments could impact refinery operations if the facility is unable to continue daily shipments of gasoline and diesel fuel through other means. At some point the refiner’s storage tanks would reach maximum capacity and refinery operations would have to be curtailed. Overall, it appears as though California is not as vulnerable to temporary pipeline closures as some other states or regions of the country.

Although throughput of crude oil and petroleum product pipeline distribution systems has increased over the last 15 years, the number of incidents involving a release has declined. In light of the fact that the average age of these pipeline systems continues to grow, a declining incident rate and a declining average quantity per release seem to be the result of increased vigilance and maintenance efforts undertaken by the industry.

Two types of tests are used to assure pipeline integrity. In a hydrostatic test, the petroleum product or hazardous liquid is removed from the pipe and replaced with water. The pipeline is pressurized to 125 percent of the maximum pipeline operating pressure and tested for loss of pressure. Another method of pipeline testing is by using devices called "smart pigs." The pig is an internal inspection device that travels through the pipeline carrying sensors, data processing electronics and data storage. The data is retrieved from the pig after the trip through a pipeline segment and analyzed to reveal the condition of the pipeline. This method is generally considered preferable to the hydrostatic test because it detects and allows the correction of problems prior to failure. It also causes less disruption to the normal operation of the pipeline and has no risk of contaminating the fuel with water.

The federal Department of Transportation's Office of Pipeline Safety (OPS) administers the national regulatory program to assure the safe transportation of natural gas, petroleum, and other hazardous materials by pipeline. OPS develops regulations and programs to assure safety in design, construction, testing, operation, maintenance, and emergency response of pipelines. OPS recently implemented more stringent standards. These are now comparable to California standards and apply to both intra- and inter-state pipelines with respect to regular testing of hazardous material pipelines.

In California, the Office of the State Fire Marshal (SFM) acts as an agent of the federal Office of Pipeline Safety with the inspection of interstate pipelines and regulates the safety of intrastate hazardous liquid transportation pipelines. SFM Pipeline Safety Division staff insures compliance with all federal and state pipeline safety laws and regulations and investigates the cause of all spills, fires, and other accidents. California standards in the past have typically exceeded minimum federal safety standards, primarily through more frequent tests of pipeline integrity. Federal regulations require that a pipeline be hydrostatically tested before initial operation. Now both California and federal regulations require that each pipeline system be tested at least every five years by an independent third party. Pipelines in a high risk category now require testing every two years. The SFM typically approves the use of smart pigs in lieu of hydrostatic testing.

Jet Fuel Infrastructure

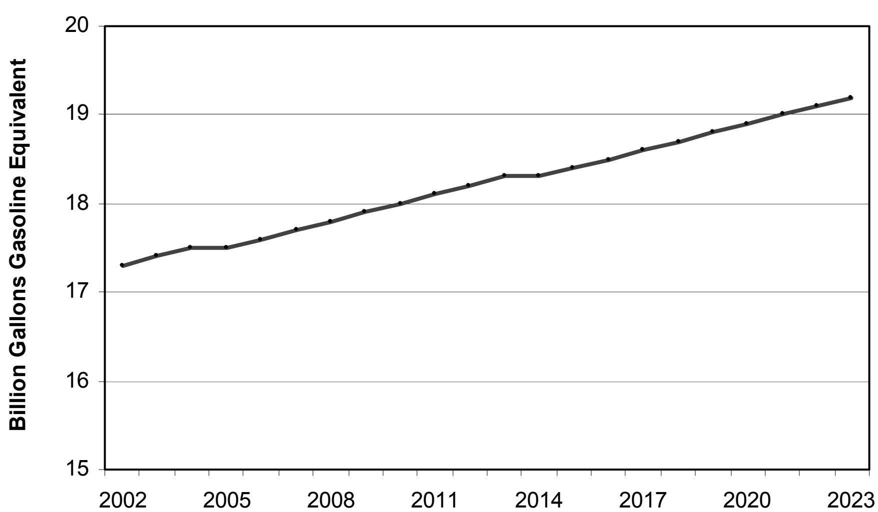
The infrastructure to receive and unload imports of jet fuel is not nearly as constrained as that for other types of petroleum fuels. In fact, due to the temporary decline in jet fuel demand, some additional import capacity was made available. It is likely that over the mid to longer term, this import capacity will still require modifications to avoid development of constraints that could impede continued shipments. Lastly, it is important to note that the distribution of jet fuel is less complex relative to gasoline and diesel fuel because there are fewer and less geographically diverse end users. In fact, the majority of jet fuel for use in California is distributed by dedicated pipelines, unlike gasoline and diesel fuel shipments that utilize a combination of shared pipelines and tanker trucks to ensure an uninterrupted stream of supply.

FUTURE SUPPLY

Gasoline and Diesel Fuels

The Energy Commission forecasts demand for transportation fuels will grow as much as 35 percent over the next 20 years. Refineries located within California will likely be able to incrementally increase their production of fuels. **Figure 3-5** shows the estimated growth in gasoline and diesel supply from existing in-state refineries.[13] The future growth is a result of estimated production capacity growth from operational and process improvements.

Figure 3-5
Estimated Supply from In-State Refineries



Jet Fuel

California demand for jet fuel recently declined following a downturn in air travel that began in 2001. But increasing passenger travel over the near-term should result in demand growth of approximately 3 to 4 percent per year. Like gasoline, demand for jet fuel is greater than the production capacity of California's refiners. As a result, jet fuel imports to California have increased to a level of about 20 percent of total demand. Jet fuel is also exported to Reno, Las Vegas, Phoenix and Tucson by petroleum product pipelines to meet the demand at airports in each of these cities. Over the next 10 years, the increased demand for jet fuel in California, Nevada and Arizona will be principally met by additional imports to Southern California.

Jet fuel, unlike California gasoline, meets an international set of specifications that vary little throughout the world. This means that jet fuel produced at almost any refinery in the world can be imported to California, vastly increasing the number of potential suppliers. Importers of jet fuel also have well developed financial instruments to hedge the risk of importing large cargoes of jet fuel over long distances that require several weeks for delivery.

In order to increase imports into California, the marine and storage infrastructure must be able to accommodate product transfers off of vessels and into the storage and distribution system.

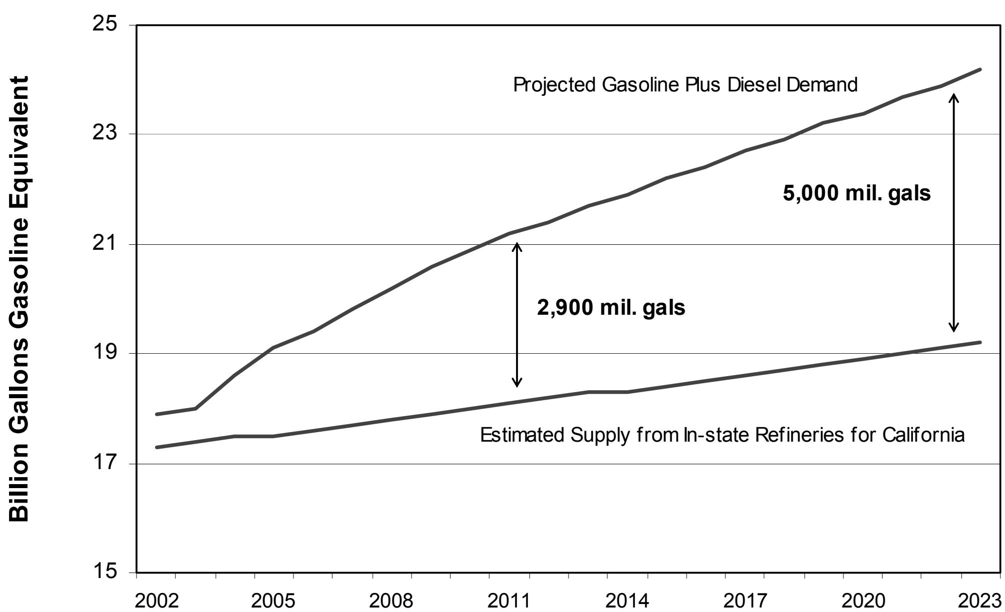
CHAPTER 4: TRANSPORTATION SUPPLY AND DEMAND BALANCE AND ISSUES

The gap between transportation fuel supply and demand will continue to widen. If the petroleum industry cannot provide sufficient fuel supplies, California will continue to experience volatile price and supply disruptions. Issues confronting California include permitting barriers currently constraining marine infrastructure expansion, uncertainty in the future plans of how the petroleum industry will increase transportation fuel supply, and the long-term viability of maintaining California's transportation infrastructure and system.

CALIFORNIA FUTURE TRANSPORTATION FUEL SUPPLY AND DEMAND

Figure 4-1 shows that in-state refining production of gasoline and diesel, will not be able to provide sufficient fuel for California's growing future demand even with continued refinery improvements.[14]

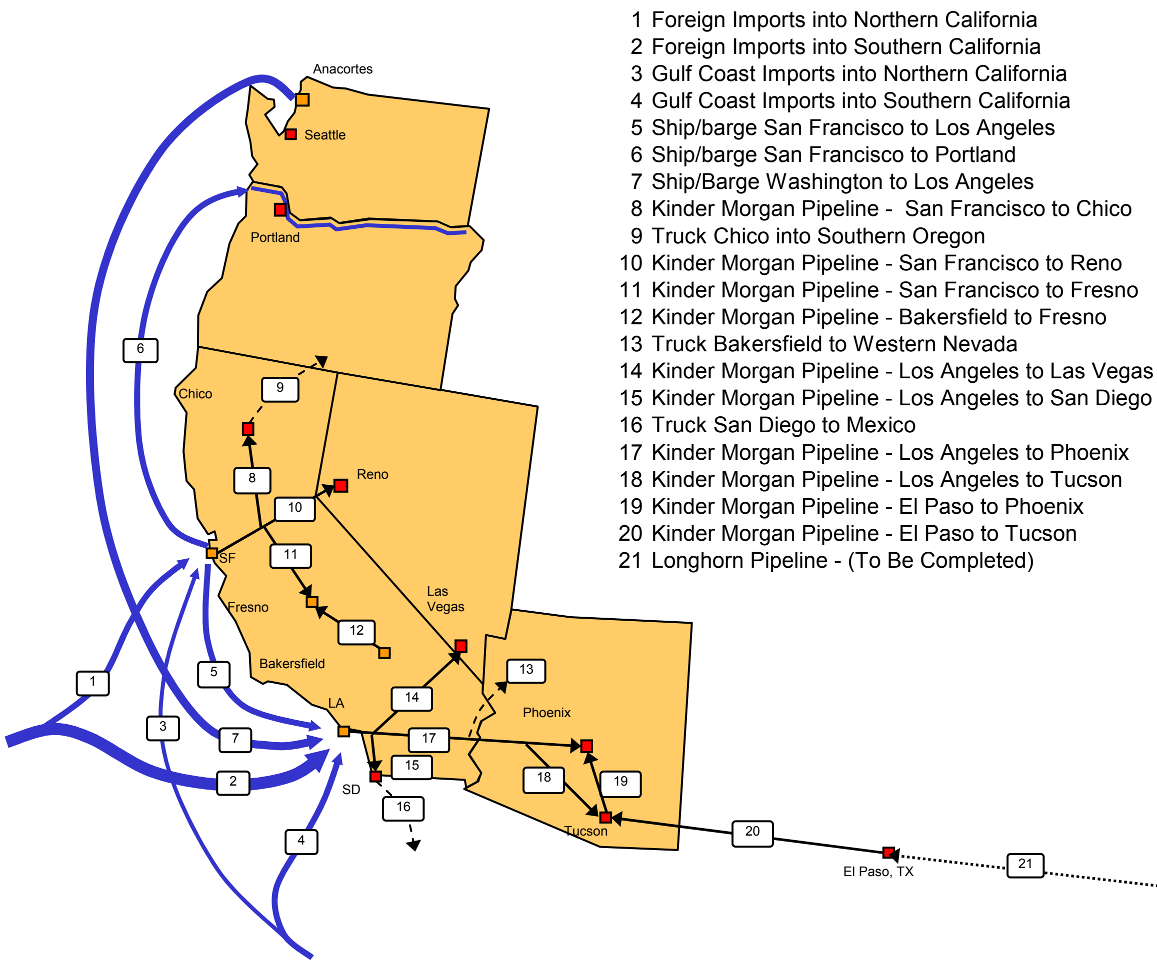
Figure 4-1
Projected Transportation Demand versus Supply



INCREASING PETROLEUM FUEL SUPPLIES

Figure 4-2 shows the petroleum infrastructure and flows for the California transportation fuel market. Demand for transportation fuels is forecast to increase over the near and long term. Over the same period, production from refineries located in the state is not expected to keep pace. As a result, imports of fuels and blending components will need to increase to ensure the continuation of sufficient supplies of transportation fuels. As shown in **Figures 4-3 and 4-4,** industry experts estimate that California will need to secure three times more gasoline and diesel from outside of California than it currently imports within the next 10 years.[15]

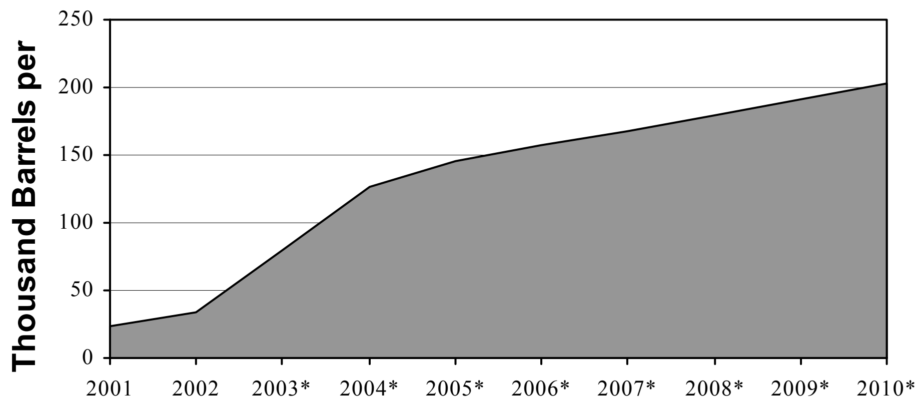
Figure 4-2
Petroleum Flows and Infrastructure



California refiners also supply the majority of transportation fuels used in Nevada and Arizona. The increased demand for these neighboring states will most likely have to be met through additional imports as well. The ability to receive additional quantities and diversity of transportation fuels at marine facilities located in Southern and Northern

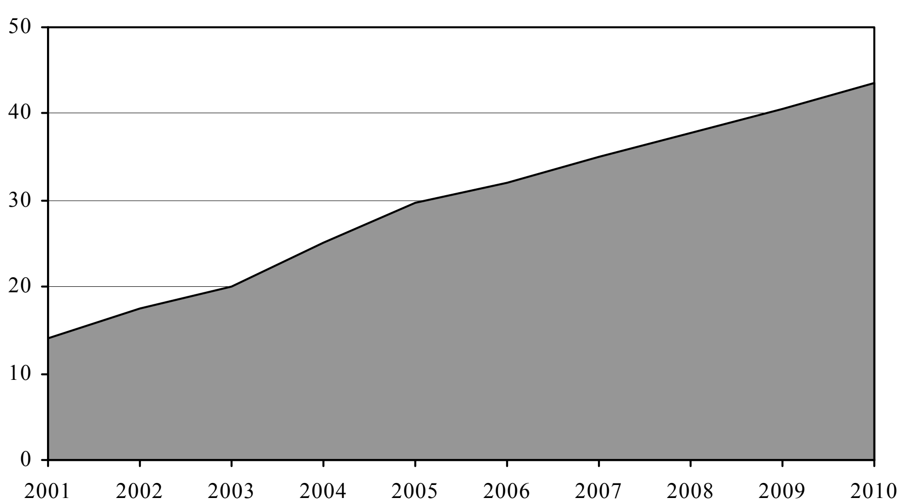
California and to distribute these fuels to terminals located throughout the State may be constrained by this additional influx.

Figure 4-3
Actual Past and Potential Future California Gasoline Import Requirements



*2003 and beyond includes an additional allowance for the estimated gasoline pool shrinkage associated with MTBE phase-out.

Figure 4-4
Actual Past and Potential Future California Diesel Import Requirements



Marine facilities have already experienced periods of delay for unloading vessels. Increasing imports will exacerbate this periodic difficulty, leading to temporary supply disruptions and associated price increases. A closer examination of capacity expansion plans is warranted to determine if the timing and capacity of these projects will be sufficient to meet anticipated needs. The network of pipelines between marine facilities and refineries is already at capacity for some pipeline segments. Modifications to marine facilities to handle additional imports also need to include increased capacities for these critical pipeline segments to avoid further supply disruptions. In some cases, the pipelines that transport petroleum products from the refineries to the terminals are also at or near capacity. Some of these pipelines are also used to transport fuel to neighboring states. During peak periods of demand, inadequate pipeline capacities can result in temporary supply disruptions. California's ability to receive and dispense adequate supplies of transportation fuels will be dependent on the scope and timing of infrastructure expansion projects. To the extent that modifications do not proceed or are unduly impeded, California's supply of transportation fuels could be in jeopardy.

Several issues may impact the supply and price of transportation fuels in California:

- A petition for waiver filed by the State of California to allow the use of non-oxygenated gasoline in certain areas of California.
- Pending legislation in Congress to modify the federal Energy Policy Act.
- A 2006 requirement to reduce sulfur content in diesel fuels throughout the U.S.
- Timeframe when world oil production peaks.

Federal Oxygenate Requirement

The federal Clean Air Act empowers the U. S. Environmental Protection Agency (U.S. EPA) to control properties of gasoline, including the oxygen content and fuel vapor pressure. Ethanol and methyl tertiary-butyl ether (MTBE) have been the primary oxygenates used by the oil industry to meet minimum oxygen content requirements established in the Clean Air Act Amendments of 1990.

In 1995, federal reformulated gasoline regulations were implemented for extreme or severe ozone non-attainment regions. Four of these regions are in California and include the Los Angeles, Sacramento, San Joaquin and San Diego areas.

Federal regulations require a minimum of 2.0 percent oxygen content by weight in non-attainment areas. Currently, these federal reformulated gasoline areas in California account for about 80 percent of gasoline demand in California. California has requested U.S. EPA to waive the oxygen requirement for federal reformulated gasoline in California in order to fully implement the revised oxygen provision of the new California Air Resources Board (CARB) Phase 3 gasoline specifications that were adopted in 2002.

Under California's new fuels specifications, a minimum oxygen content is not needed to make reformulated gasoline that meets all emission reduction requirements. As a result, the State of California has petitioned the U.S. EPA for a waiver from federal law requiring the use of oxygenated gasoline in ozone non-attainment areas. The U.S. EPA denied this petition, prompting the state to appeal the decision to the Ninth Circuit Court of Appeals. On July 17, 2003, the court rendered an opinion vacating the U.S. EPA's denial and ordering the agency to reconsider California's waiver request. As a result, California will continue to pursue a California waiver from U.S. EPA's oxygenate requirements.

California's request for a waiver is based on several studies including the U.S. EPA's own Blue Ribbon Panel finding that a minimum oxygen content is not necessary to make gasoline that meets emission reduction requirements. Furthermore, California refineries need the ability to make gasoline with or without oxygenates as situations warrant. Refineries need the flexibility to produce affordable and available gasoline without sacrificing air and water quality.

With the phase-out of MTBE in California's gasoline supply, ethanol becomes the only gasoline oxygenate additive approved for use in the state. The transition from MTBE to ethanol in the state's gasoline markets is progressing smoothly and, by the beginning of 2004, most California gasoline will contain approximately six percent ethanol, resulting in 760 to 990 million gallons per year of ethanol use. The longer term outlook for ethanol use as a blending component in California gasoline depends on the future of federal oxygenated gasoline requirements, progress toward air quality attainment in areas of the state that fall under these federal requirements, and the possible enactment of a federal "renewable fuels standard," among other factors.

The phase-out of MTBE will decrease California refinery production capability. First, ethanol can only be blended at a concentration of six percent by volume, compared to the 11 percent by volume for MTBE. This change alone represents a decline in total gasoline production supply of five percent. Secondly, the use of ethanol during the summer period necessitates other operational changes by refiners to ensure that the gasoline blended with the ethanol will comply with all of the specifications, especially the volatility limit of 7.2 pound per square inch (psi) for summer grades of gasoline.

Since ethanol is more volatile than MTBE, refiners have to adjust gasoline blending practices by reducing other components (such as pentanes) in the production of gasoline. This means that gasoline production would be reduced another five percent. The loss of in-state refining production capability can be made up by refiners through such measures as expanding alkylate production, increasing imports of blending components, or converting conventional gasoline output to reformulated gasoline output. Due to these other factors the impact of the MTBE phase-out on California refinery gasoline production capability is estimated to be limited to between three and four percent.

These changes in process operations, modifications to individual refinery units, construction of new ethanol storage tanks, and installation of equipment to receive and blend ethanol, along with increased imports of expensive gasoline components are estimated to raise the average production cost for California gasoline by six cents per gallon. If a waiver from the federal oxygenate requirement were granted, these estimated cost impacts would be reduced by 50 percent.

Pending Federal Legislation to Modify the Energy Policy Act

Congress is deliberating new national energy legislation that includes major provisions relevant to the state's ethanol-blended gasoline supply. The current language includes:

- Requirement for a Renewable Fuel Standard (RFS). Requires gasoline sold in the U.S. (except Alaska and Hawaii) to contain renewable fuel, beginning at a volume of 2.6 billion gallons per year in 2005, increasing each year to 5 billion gallons per year by 2012.

- Restrictions on the use of MTBE. Prohibits the use of MTBE in gasoline four years after enactment, except in states that act to specifically authorize its use.

- Elimination of Oxygen Content Requirement for Reformulated Gasoline. Strikes the Clean Air Act requirement for use of oxygenated gasoline in air quality non-attainment areas.

These provisions involve the supply and price of ethanol and effects on California gasoline:

- Ethanol Supply Adequacy - The RFS requirement for five billion gallons of ethanol use nationwide by 2012 should, based on Energy Commission analysis, be met by domestic U.S. production sources.

- Ethanol Price Impact on Gasoline Prices - Increasing demand for ethanol to meet the increasing requirements of a national RFS could create upward pressure on ethanol prices. However, the price of ethanol used as a six to ten percent gasoline additive stands to modestly impact gasoline prices.

- The price and supply of ethanol are important components and in the near-term, are critical to ensuring safe and affordable supplies of gasoline. The Energy Commission will continue to monitor this pending legislation and its impact on California's transportation fuel price and supply.

Federal Low Sulfur Fuel Specification[16]

In 1999, the U.S. EPA issued a rule that requires sulfur in diesel be reduced from today's 500 parts per million (ppm) to an average of 30 ppm. The effect of this new rule is estimated to directly increase refiner's cost to produce fuel that complies with the new rule. The new fuel must be available at retail stations by September 1, 2006, although a phase-in option allows up to one-fifth of all diesel fuel produced to meet a limit of 500 ppm through early 2010. This new requirement is expected to increase the cost of producing diesel fuel by several cents per gallon. Compliance costs in California will be somewhat less because several California refineries have already made much of the investment needed to produce lower sulfur diesel.

Supply shortages and/or disruptions in the flow of product generally lead to price spikes. It is likely that the new requirement will contribute to higher price volatility, particularly during the transition period from the current fuel specification to the new fuel specification. The volatility will likely be a result of fewer refiners manufacturing diesel that meets this new specification and transport issues in moving the new fuel through the existing pipeline system.

CARB has recently adopted a rule to implement the same federal sulfur limits on the same schedule for highway diesel fuel use, however the CARB rule also extends the low-sulfur requirement to off-road vehicles and to stationary engines that use diesel. In California, these sources must begin using low sulfur diesel in 2006.

The supply, availability and price of diesel in California must be monitored as this fuel's use has an enormous impact on the agriculture and trucking industries in California. Issues related to implementing the transition to lower sulfur diesel may cause supply constraints or higher prices. The Energy Commission will continue to monitor the progress of refineries to meet the CARB regulation, as well as other states' implementation progress.

World Oil Supply

As shown in **Figure 4-5**, in 2002, California refineries' crude oil supplies came from in-state sources (48 percent). Alaska accounted for 22 percent, and foreign sources for 30 percent. Regardless of the source of crude oil, prices from all these sources tended to rise and fall together, the differences in price taking into account premiums for the differences in quality.

In the past, politically induced disruptions have been the primary cause of world crude oil price spikes. These price increases often endure for short periods of time after which prices return to their historical averages.

California is a major consumer of petroleum and will become increasingly reliant on foreign sources of petroleum. The future availability of world oil supply is a concern to maintaining affordable fuel supplies to California. Experts offer varying opinions on whether a production peak will occur; and if there would be a peak, the timeframe that a production peak would occur.

Figure 4-5
Sources of Crude Oil for California Refineries 2002

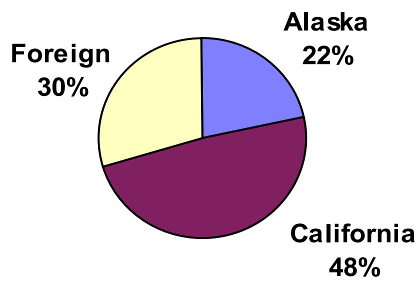


Figure 4-6 shows that the United States Geological Survey (USGS) petroleum assessment indicates an "ultimate resource base" of conventional oil of three trillion barrels.[17] Ultimate resource base includes historical production, current proved reserves, possible reserves growth at existing fields, and further undiscovered resources that will be added to reserves. This does not include frontier areas, small accumulations, or substantial unconventional resources, such as heavy oil and oil sands or methane hydrates. Just under one-half of this base has already been produced.

Figure 4-6
World Petroleum Assessment

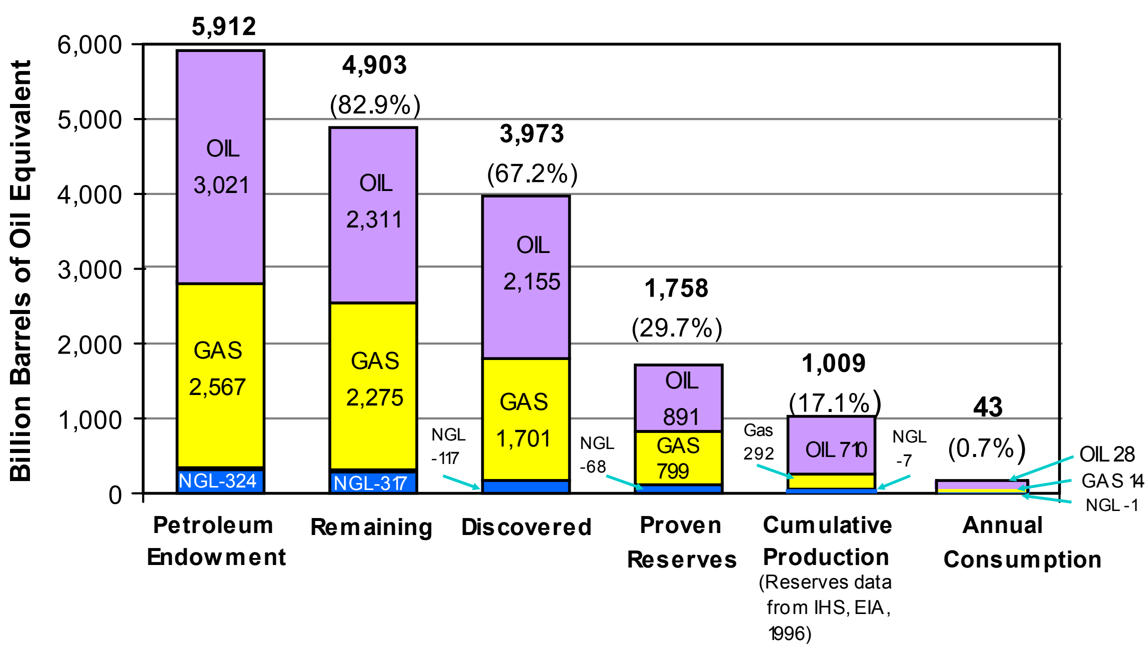
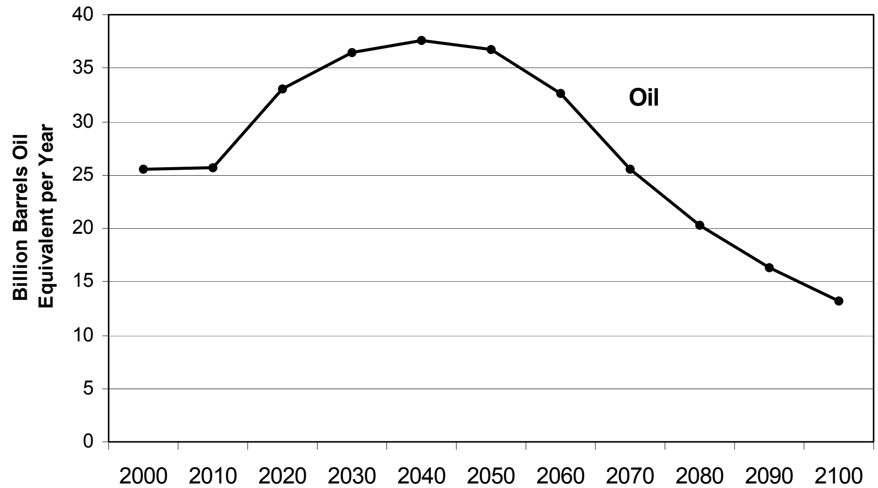


Figure 4-7 presents a USGS scenario of a world oil production peak.[18] Depending upon USGS assumptions regarding future discoveries and rate of consumption, world oil production could peak as soon as 2020 but perhaps as late as 2040. However, this time period can shift depending upon increasing petroleum demand and/or reductions in

demand for petroleum products throughout the world. Additionally, more proven reserves could be developed in the future from heavy oil and oil sands or improvements in oil recovery technology could increase production. These additional reserves will be developed if the economics show that there is a benefit to investing in their recovery.

Figure 4-7
Estimate of World Oil Production Peak



The Energy Commission will monitor the world oil supply market to provide as much advance planning opportunity to respond to significant changes in world oil production. Based on expert opinions, the Energy Commission will undertake monitoring activities of production profiles, reserves to production ratios, industry and related financial markets, global oil substitution and demand reducing trends, Organization of Petroleum Exporting Countries (OPEC) market share trends and crude oil price projections.

REDUCING PETROLEUM DEPENDENCE

As California's future population and economic output grow, our demand for transportation services and fuels also grow. While in-state refining capacity continues to grow to meet increasing demand, it will not be able to keep pace with the rate of future demand growth. Without increasing the fuel supply infrastructure to import additional crude oil and transportation fuel supplies, California will continue to experience sudden price increases for both gasoline and diesel fuels.

California will experience even greater economic and environmental burdens if it continues to rely exclusively on its current transportation energy supplies and does not develop other energy resource options.

As California continues to rely on petroleum, it will increase its growing reliance on foreign imports. Like Alaska and California petroleum resources, foreign oil resources will also reach a peak in production before declining. Experts, at this time, continue to debate the timeframe that world petroleum resources will peak based on known and available data. Some experts believe the petroleum peak will occur in the next 10 to 20 years. Other experts and the oil industry maintain technological improvements to extract petroleum, economics and additional discoveries will extend the peak well into the next century.

Energy resources needed to meet California's transportation energy demand will be fossil fuel-based and their combustion will release greenhouse gases. Greenhouse gas emissions from human activities are likely causing dangerous warming of the earth's atmosphere, which may have significant economic, environmental, and ecological impacts. As the effects of climate change intensify, transportation fuel options will need to focus on efficiency improvements and fuels and energy sources with potential for lower greenhouse gas emissions.

One potential new supply for transportation fuel could be developed from coal. Fischer-Tropsch diesel is a product that is manufactured from natural gas, coal and/or biomass. Deriving Fischer-Tropsch diesel from coal is one means to improving the long-term supply of diesel and reducing California's dependence on petroleum. The U. S. has the world's largest coal reserve with over 275 billion tons. This is the equivalent to over 20 trillion gallons of Fischer-Tropsch diesel. Potentially using sequestration technology to reduce carbon dioxide (CO_2) emissions would resolve concerns regarding greenhouse gas emissions. It is possible that this resource could become a viable means of providing new diesel supplies to California. The expected price premium for coal-derived Fischer-Tropsch diesel is approximately 10 cents per gallon higher than natural-gas derived Fischer-Tropsch diesel, at current energy prices. The Energy Commission should continue to monitor developments of Fischer-Tropsch diesel to determine if it can contribute to California's transportation energy needs.

Another potential new supply is oil from oil sands. Oil sands are deposits of bitumen, which must be heavily processed before it can be used in refineries to produce gasoline and other fuels. Oil sands are not included in the USGS world petroleum assessment data shown in Figure 4-4. Some estimates place approximately 1.7 trillion barrels of oil from oil sands of Canada, and 15 percent (255 billion barrels) as recoverable. Other countries also have oil sand resources, including the United States. Canada's production of oil from this resource is approximately 700 thousand barrels per day currently and this could increases to more than 2.2 million barrels per day by 2025. The most significant barrier to delivering this product to the United States is lack of pipeline capacity and infrastructure to transport the product.

CHAPTER 5: CALIFORNIA NEEDS TO REDUCE ITS VULNERABILITY TO SUPPLY DISRUPTIONS AND PRICE SHOCKS

California has experienced short-term price spikes over the last several years exacerbated by physical constraints in California's marine infrastructure and the transportation fuel industry's storage capacity. Removing these constraints will allow for more flexible supplies of gasoline and diesel fuels, which can significantly reduce price volatility.

In the last few years, California motorists have experienced significant short-term increases, or "spikes" in the price of gasoline. The state's gasoline refineries are operating at near maximum production, and when an unplanned refinery outage occurs, especially when gasoline inventories are low, the price of gasoline can spike. Outages drive the price higher because of the temporary imbalance between supply and demand. The price increase required to restore this balance can be significant due to a very low demand response from California motorists. The reason for this low demand responsiveness is California motorists have little alternative to gasoline use in the short run.

Gasoline sold in California requires a unique, less-polluting formulation. This means that sources of supply outside the state are limited. Since California is not connected by pipeline to major refinery centers elsewhere in the country, imported gasoline must be brought in by marine tanker. In the event of an in-state supply disruption, locating and importing replacement gasoline can take from two to six weeks. Prices often remain at high levels until shortly before these additional supplies arrive.

CONSEQUENCES ON AVAILIBILTY AND PRICE OF FUELS

California's gasoline price volatility, of which price spikes are the most obvious feature to motorists, can result in short-term prices significantly higher than in the rest of the country. The difference in retail prices between California and other regions, typically 5 to 20 cents per gallon, can increase to 50 cents or more per gallon as a result of in-state supply disruptions. During the latest price spike episode in early 2003, average retail prices in California increased by 57 cents per gallon and reached levels 40 cents higher than average prices elsewhere in the U.S.

Gasoline is a commodity that is bought and sold in wholesale, or "spot," markets. Market traders purchase gasoline, in bulk, for a certain price. A trader can sell that bulk gasoline at a set price when the cargo is delivered. Depending on the demand for the cargo when it arrives (which is based on a combination of consumer demand and current inventory levels) the cargo can have less or more value than when it left its site of origin.

The most noticeable times when cargos can gain value is when the state's refineries experience supply disruptions. Prices will remain high for a short period of time and then fall when the refinery is repaired and/or imported cargos arrive. At times like these, consumers will pay more for transportation fuels. Similarly, when there are few supply disruptions or refinery outages and inventories are plentiful, consumers will benefit with lower prices for transportation fuels.

Gasoline in California, like many other commodities is bought and sold in a wholesale, or "spot," market and in a forward market. The difference, or "spread," between the spot prices and the forward price (the negotiated price for a future delivery) of gasoline is a key driver of the level of private inventories. **Figures 5-1 and 5-2** show the relationship between the value of future prices and level of gasoline supply inventories. **Figure 5-1** plots the daily one-month forward or projected future price minus the spot or actual price for 2002.[19] The points labeled 1, 2, and 3 indicate when the forward price was much lower than the spot price.

Figure 5-1
California One Month Forward Price Minus Spot Price
January 2002 - December 2002

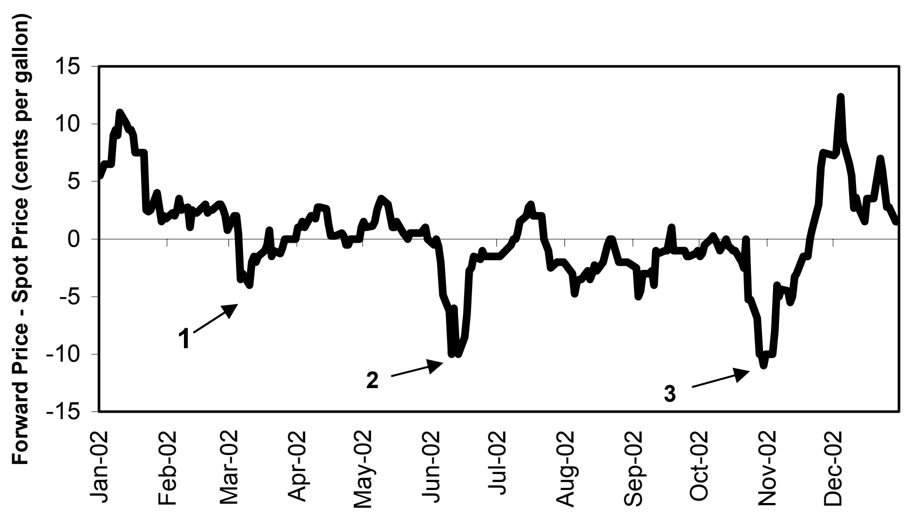
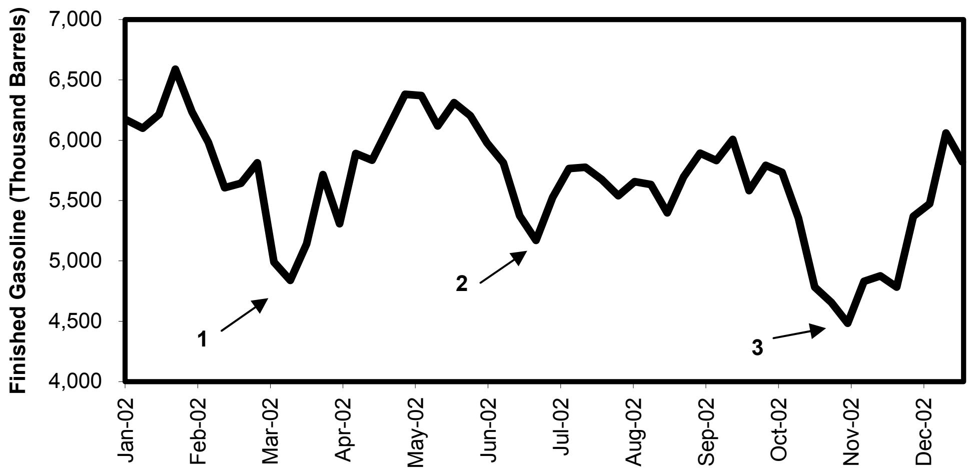


Figure 5-2 shows average weekly inventory holdings for the same year. As the points labeled 1, 2, and 3 on each graph indicate, inventories are drawn down sharply when the forward price is much lower than the spot price.

Figure 5-2
California Weekly Total Gasoline Inventories
January 2002 - December 2002

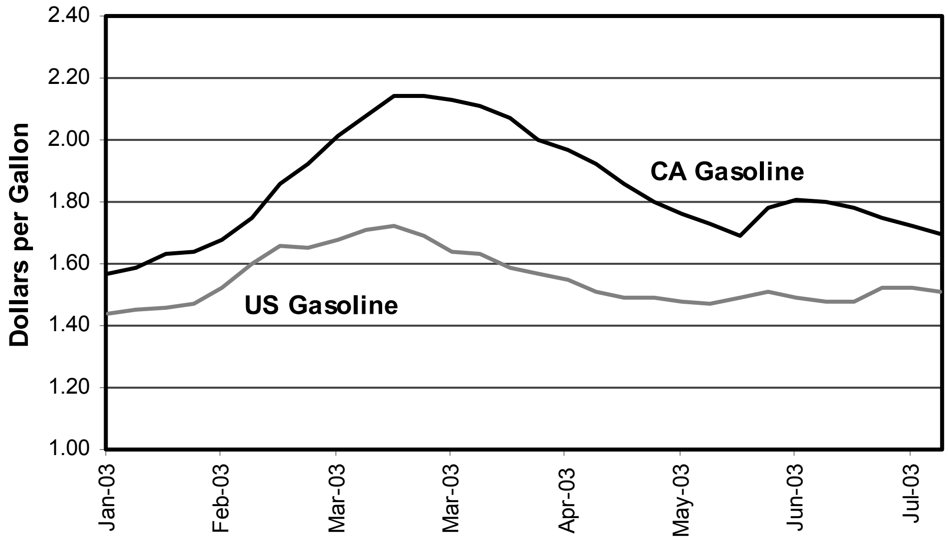


California's gasoline markets will continue to be subject to occasional price spikes for the indefinite future. When unanticipated refinery outages occur in conjunction with low gasoline inventories prices can spike significantly until additional supplies are obtained. These supplies are often imported by ocean tanker from refineries overseas and can take three to six weeks to arrive. Gasoline price increases in early 2003 were driven primarily by unusually high crude oil prices due to the impending threat of war in Iraq. Other contributing factors included an oil strike in Venezuela and a cold winter in the Eastern U.S. that increased demand for heating oil.

Circumstances unique to California also contributed to higher gasoline prices in the spring of 2003. There were some concerns in the industry that California refiners were having difficulty making gasoline that could meet new summer specifications. Although the phase-in of ethanol ultimately went smoothly, rumors and speculation around this issue caused significant upward pressure on gasoline prices in California. In addition, gasoline supplies were especially tight during this time frame because several California refiners were down for maintenance longer than originally anticipated and shipments of gasoline to Arizona from Southern California refineries were greater than normal, contributing to the state's temporary supply shortfall. Arizona experienced a pipeline problem during the summer 2003 that restricted delivery of gasoline from El Paso refineries. The impact on California was similar to what it experienced in the spring of 2003 when Arizona needed additional gasoline supply from California. The increased shipments of gasoline from Southern California refineries to Arizona contributed to the state's price spike in August of 2003.

Figure 5-3 shows the impact these events had on the price of gasoline in early 2003. Average U.S. retail prices rose from $1.44 to $1.73 per gallon over a ten week period. At the same time, California gasoline prices rose even more precipitously, from $1.58 a gallon on January 1, to a record setting $2.15 a gallon on March 17.

Figure 5-3
Retail Gasoline Prices – California versus U.S. All Formulations
January 2003 – July 2003



OPTIONS TO REDUCING PRICE VOLATILITY

In response to continuing periods of gasoline price volatility and their impact on consumers, the Attorney General examined the causes of price spikes. The Attorney General issued the ***Report on Gasoline Pricing in California***, issued in May 2000.[20] The Attorney General recommended that the state investigate the possibility of a "strategic fuel reserve," consisting of gasoline kept in public storage tanks that would be available to private suppliers through a daily auction. The intent behind such a reserve is to make additional gasoline available to the California gasoline market during supply disruptions, and thereby reduce, or "dampen," price spikes. This recommendation led to the passage of Assembly Bill 2076.

Assembly Bill 2076 (Shelley, Chapter 936, Statutes of 2000) directed the Energy Commission, among other things, to assess the feasibility of operating a state strategic fuel reserve (SFR) to insulate consumers and businesses from the substantial short-term price increases arising from refinery outages and other in-state supply disruptions.

The Energy Commission sponsored a study to measure the potential benefits to California consumers from reduced expenditures on gasoline *if* a strategic fuel reserve could dampen price volatility. The study, which assumed that the SFR would work as envisioned, analyzed the probability of refinery outages to estimate the costs of price spikes to consumers in a typical year. Assuming that a reserve would eliminate spikes above ten cents per gallon, the study estimated a "base case" annual benefit to consumers of $400 million. With different assumptions from the base case, the study yielded a range of potential benefits from $140 to $607 million per year.

To provide benefits to California consumers, an SFR must significantly increase the amount of gasoline available in the market during a refinery outage or other event in order to effectively mitigate a price spike. In addition, an SFR would introduce a new dynamic into the California gasoline market that would offset the benefits of an SFR to the California motorist.

The Energy Commission found that a strategic fuel reserve, however, could have several unintended consequences, which could limit its effectiveness as a tool to moderate gasoline price spikes and could reduce the total supply of gasoline in the state. These unintended consequences included:

- A reserve could displace private inventories,
- A reserve could offer profit-making opportunities that would reduce its effectiveness, and
- A reserve could reduce the total supply of gasoline in California.

In addition, the Energy Commission has determined that investment in private storage capacity is increasing, which reduces the need for an SFR.

Severe price volatility is likely to continue in California, at least for the next few years. Therefore, to reduce price volatility, the Energy Commission considered the following alternatives:

- Stimulate the California gasoline forward market through state participation,
- Identify the steps necessary to enhance the state's marine infrastructure, and
- Streamline the storage infrastructure permitting process.

State Participation in Forward Markets

The intent in the first alternative is to increase liquidity (the number of trades) in the gasoline forward market through state purchases of forward contracts. If more buyers of forward contracts were available, importers, who sell forward contracts, might find it easier to hedge the risk that gasoline prices could fall while the cargo is in transit. Importers might then be willing to bring more cargos into California, which could increase available supply during a disruption.

A study sponsored by the Energy Commission compared the California forward market for gasoline with other forward markets.[21] The study found that neither the number of trades nor the number of participants in the state gasoline forward market appears to be especially low in comparison with other forward markets. In addition, the study found little evidence that a lack of liquidity in the forward market impairs prospective importers. Therefore, the forward market option was not considered further to address reducing price volatility.

Identify the Steps Necessary to Enhance Marine and Pipeline Infrastructure

The Energy Commission sponsored a study of California's marine infrastructure to assess its ability to accommodate imported petroleum products.[22] The study identified the current and future constraints within the system of wharves, storage tanks, and pipelines that could impair the ability of importers to deliver cargos to the state. The Energy Commission believes that these constraints do impact imports of gasoline, and that this may reduce the supply of gasoline available during a disruption.

California imports both crude oil and petroleum products to meet state demand for fuels. Over the next five to ten years, demand for gasoline is expected to grow at a rate of almost two percent per year, while the capacity of California refineries to produce gasoline is not expected to keep pace. Consequently, imports of gasoline as well as crude oil will need to increase.

The study for the Energy Commission indicated that the state marine infrastructure for petroleum products is at or near the limits of throughput capacity, and unless the infrastructure is expanded, additional imports will increase marine congestion in California. The potential problems are most serious in Southern California, where the bulk of the increased quantities of imported crude oil and refined petroleum products will be received.

Marine vessels require storage tanks of sufficient capacity to be able to offload their cargos in a timely manner, avoiding costly demurrage fees and reducing the risk of creating additional scheduling conflicts for other vessels. Access to storage tanks is especially limited in Southern California. In particular, two of the three facilities used to receive gasoline and blending stock are highly utilized and constrained by bottlenecks that prevent increased imports.

If these constraints and bottlenecks can be alleviated to some degree, imported gasoline supply could reach the California market more quickly during a refinery outage, helping to dampen price volatility. On the other hand, if marine infrastructure capacity does not expand, volatility could become even more severe. The length of time and the complexity of acquiring permits to construct facilities were identified as a major impediment for adequate marine and storage facilities.

Permits for expansion projects involving petroleum product pipelines can be especially difficult to obtain because of the multiple jurisdictions and interveners that become involved. In addition, the ability of common carrier pipeline companies to pass along the costs of these types of projects is heavily regulated and routinely litigated which can diminish the likelihood of a successful and timely pipeline expansion project. An assessment should be undertaken to determine the extent of these pipeline infrastructure constraints, what steps the industry is currently undertaking to expand capacity, and what role the state could play to facilitate an expedient resolution to this growing concern.

Streamline the Storage Infrastructure Permitting Process

The Energy Commission is aware of 1.4 million barrels of private storage capacity that are either under construction or where construction is planned in the next several months.[23] Thus, conditions in the California gasoline market may improve slightly in the near future. Increased private storage could result in more gasoline inventories available to the market during a supply disruption.

However, all of these storage projects have been undertaken using existing permits. Future projects to construct additional storage tanks could require more extensive environmental assessment and a lengthier approval process. Based on an Energy Commission survey of the petroleum industry, the state's petroleum product storage infrastructure is still inadequate, even with these new projects, and that the permitting process may unduly burden applicants and agencies.[24]

The high costs of the permitting process result in a shortage of storage capacity. These costs lead to higher lease and rental rates for tanks, so gasoline suppliers hold lower inventories than they might otherwise choose. This results in lower inventory available during a refinery outage and therefore more gasoline price volatility. In addition, higher lease and rental rates raise the operating costs to suppliers, resulting in higher average market prices.

The Energy Commission sponsored a detailed study on the permitting of petroleum product storage facilities.[25] The study examined the process by which petroleum industry participants obtain the permits required for the construction or acquisition of petroleum product storage facilities. In addition, the study identified bottlenecks, redundancies, and unnecessarily burdensome regulatory processes, and recommended improvements in the permitting process. The Energy Commission used the study to identify and recommend actions to improve the permitting process. The most critical action was to provide statewide authority for implementing and enforcing the Permit Streamlining Act.

The Permit Streamlining Act (PSA) establishes strict timelines for agencies to conduct permit application reviews and issue decisions. The PSA requires state and local agencies to list the information and criteria that they will use in evaluating a permit application. These timelines are frequently not met, without penalty to the permitting agency. Little effort appears to be made to comply with the PSA, since the PSA is not very well known among stakeholders in the permitting process. No agency within California is responsible to implement the PSA, and this appears to be a fundamental problem. This issue is very complex, but a permitting process solution could yield significant benefits by eliminating duplicative efforts on the part of agencies and applicants and providing a time-certain process with decision-making authority.

The state has dealt with similar problems in the past. In response to concerns about the power plant siting process, the Legislature passed the Warren-Alquist Act in 1974, establishing a state permitting agency for power plants. The legislation gave the Energy Commission exclusive authority over thermal electric generating power plants 50 megawatts or larger as well as related facilities such as transmission lines. As a result, the Energy Commission developed a 12-month process for certification of applications.

As the lead agency under the California Environmental Quality Act (CEQA), the Energy Commission is required to consult with responsible local, state, and federal agencies as part of its review process. The Energy Commission's power plant licensing process has proved to be very effective in assuring the timely review and approval of new generating capacity in California because it: 1) consolidates all state and local agencies into a single permitting process, 2) has the ability to override other state and local agency decisions, 3) involves extensive public participation, and 4) has a certified CEQA equivalent review process.

CHAPTER 6: ADDITIONAL FUEL SUPPLIES ARE NEEDED TO MEET FUTURE DEMAND

There will be a significant and growing gasoline supply deficit that will need to be met by importing transportation fuels. Available information on potential supply options raise the concern that California may experience higher and more volatile fuel prices as a result of inadequate supplies being available in the near future.

TRANSPORTATION FUEL SUPPLY SUFFICIENCY

Given the important role that transportation fuels provide for Californians, in terms of the economy and quality of life, it is imperative that the state be fully informed on how private industry intends to supply future transportations demand needs. If shortfalls are identified, then the state can be positioned to take the appropriate actions to address shortfalls.

Some of the opportunities to maintain sufficient, secure and affordable supplies in the near term include, but are not limited to expanding marine infrastructure and increasing in-state transportation product storage capacity. In addition, there may also be opportunities to build product transfer systems, such as pipelines.

While it is clear that the state needs additional supplies of transportation fuels, it is not clear which of the options to create those additional supplies provide the best means or if sufficient supplies can be developed, to achieve that goal.

While the Energy Commission receives data on current crude oil and petroleum product production, shipment, prices, inventory, and storage levels from refiners and major petroleum firms, the Energy Commission does not have access to future expansion and construction plans to this industry. This information is highly proprietary and market sensitive and not publicly available due to the competitive nature of the industry. If the Energy Commission were able to acquire this information confidentially then the Energy Commission could determine if industry will or will not be able to provide adequate supplies to meet future transportation fuel demand. In addition, the Energy Commission would be able to determine bottlenecks and impediments to expansion and construction that might adversely impact the delivery of future transportation supplies and identify action that the state could assist the industry to bring future projects to fruition.

TRANSPORTATION FUEL SUPPLY OPTIONS

To meet current California gasoline demand, as well as exporting gasoline products to neighboring states, an additional 3.5 million gallons of gasoline and blend stocks per day must be imported. Given estimated in-state refining capacity growth, projected gasoline and diesel fuel demand will create an annual supply deficit of 2.9 billion gallons by 2010 and five billion gallons by 2023. To eliminate the projected supply deficits, increasing levels of gasoline and diesel product and blend stock will need to be imported.

Potential actions for increasing supply include incremental production increases at refineries, port expansions to receive increased levels of imported products, additions to storage capacity in-state, increased pipeline infrastructure to California and/or the Southwest states and demand reduction measures (such as increased vehicle efficiency, and vehicle maintenance). If new refinery capacity is proposed to help increase supplies, California would need to ensure that port, storage and infrastructure can support the increased deliveries of crude oil and blending components.

Aside from these actions that can help increase transportation fuel supply to California, there may be actions that restrict increased supplies, such as the possible increase in demand for ethanol throughout the U.S. as a result of changes to federal law and the implementation issues related to federal and state lower sulfur diesel regulations.

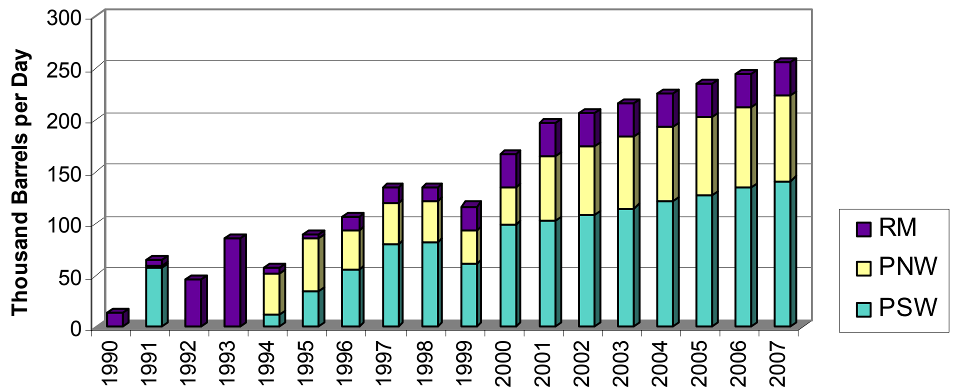
Refinery Production

Output from refineries throughout the west has increased, without increasing the number of refineries. The refining industry has shown it is capable of increasing refinery output through improvements in refining technologies. **Figure 6-1** illustrates the refining industry's capability to increase production from existing facilities.[26] At this time, the ability of refiners to continue to increase output is unclear.

Marine Imports

Imports via marine shipments will very likely be the way that California will meet its future transportation fuel supply needs. Marine imports can only be accomplished if space is available at docks for ships to berth, if the depth of the access waterways is sufficient to allow passage of large ships, and if storage for unloading and transferring materials is available. It will be important to monitor and evaluate the development of marine infrastructure to support increased deliveries of crude oil and transportation fuel products to California.

Figure 6-1
Cumulative Incremental Production of Pacific Northwest (PNW), Rocky Mountain (RM) and California (PSW) Refineries Total Gasoline
Thousand Barrels per Day, Base Year – 1989



Unocal Patent

The Unocal Patent refers to five sets of gasoline patents that primarily cover most formulations of California and federal reformulated gasoline that could be produced during the summer months. Unocal received approval for the first set of patents in February of 1994, but did not publicly announce the nature of the patent or the intent to collect royalties until January 31, 1995. Subsequent litigation by a number of oil companies culminated in a court ruling that required all refiners who produce gasoline that infringes on the first patent a royalty amount worth 5.75 cents per gallon. Unocal has since obtained licensing agreements with 8 companies (not associated with the lawsuit) that permit them to dispense gasoline that infringes on any of the 5 sets of Unocal patents for a fee of between 1.2 and 3.4 cents per gallon. The dispute involving the legitimacy of the patents is now embroiled in an administrative complaint that was filed by the U. S. Trade Commission on March 4, 2003.

The Unocal patents can impact California's gasoline market in two ways: increased costs for refiners and reluctance of outside parties (gasoline importers) to transport finished gasoline to the state. Refiners who attempt to avoid infringement by "blending around" the patent properties increase their operating expenses and decrease the flexibility they have to produce finished reformulated gasoline. These types of activities can increase costs for California consumers and elevate the risk of supply problems during periods of refinery disruptions. Supply of gasoline can also be impacted by the potential diminishment of the number of gasoline suppliers who could send cargoes to California because of a reluctance to infringe on the Unocal patents which would put the company at risk of having to pay a royalty fee or damages which could reduce or eliminate the possible profits from an imported cargo of gasoline. Therefore, gasoline suppliers outside of California may be more willing to send cargoes to alternative markets that have gasoline specifications which fall outside the Unocal patents.

Pipeline System

Importing transportation fuel products into California could be supplemented from the pipeline system. The pipeline system that serves the Southwestern states could be expanded to allow more product to flow to the Arizona and Nevada markets. One such project could expand the capacity of the existing El Paso to Phoenix pipeline as early as the end of 2004. This project, and others like it, is important to the extent that it reduces the demand on California refiners to export product to Arizona and Nevada. It is important to monitor projects that affect supplies of product that could impact the California supply situation.

Ethanol

The phase-out of MTBE will be completed by the end of 2003. The continued use of MTBE was determined to pose a risk to California's environment and was scheduled to be eliminated from the state's gasoline supply by the end of 2002. Concerns about adequacy of ethanol and gasoline supplies prompted Governor Davis to delay the phase-out until the end of 2003 to ensure that all of the necessary modifications could be completed to allow for a smooth transition. But a number of companies operating refineries in California decided to eliminate the use of MTBE in advance of the new deadline.

ConocoPhillips was the first company to eliminate their use of MTBE, completing the transition for both of their refineries during 2001. BP, ChevronTexaco, ExxonMobil and Shell significantly decreased or completely eliminated the use of MTBE at six of their facilities by early 2003. These companies are collectively dispensing between 60 and 70 percent of the state's gasoline. Most of this gasoline contains ethanol at a concentration of 6 percent by volume. Although some refiners produce a portion of their California reformulated gasoline without the use of MTBE or ethanol (non-oxygenated gasoline), it is unlikely that the industry will continue this practice after the end of 2003 due to an inability to mix these two different types of gasoline together in the same storage tank.

Currently, California has a number of rail lines linking California terminals with the Midwest, which is the predominant source of California's ethanol supplies. Union Pacific delivers ethanol to terminals in Sacramento, Stockton, San Francisco and Los Angeles. The Burlington Northern Santa Fe rail lines are also used to deliver ethanol directly to Los Angeles terminals and will soon have the capability to deliver ethanol to San Diego. The current storage capacity for ethanol in California is approximately 900 million gallons.

Possible actions that could impact the demand for ethanol include new federal legislation. The new federal legislation, if passed, would require increased amounts of ethanol to be used in the U.S. if other states opt to use ethanol as an oxygenate. Additionally, the California petition for a waiver from the federal oxygenate requirement (except in certain geographic areas within California) would, if granted, impact the demand for ethanol.

The potential impact of this action and the supply and demand for ethanol will continue to be monitored.

Low-Sulfur Diesel

As California and the rest of the nation transition to low-sulfur diesel fuel, temporary production and supply problems may occur. Early implementation issues associated with low-sulfur transition may affect supply and increase price volatility. The supply, availability and prices of diesel must be monitored as this fuel's use has an enormous impact on the agriculture and trucking industries in California.

CHAPTER 7: SUPPLY AND DEMAND MEASURES TO TRANSITION TO EFFICIENT, ENVIRONMETALLY SOUND AND DIVERSE ENERGY FUTURE

California can transition to a more efficient, environmentally sound and diverse transportation energy system that reduces our petroleum dependence and our contribution to greenhouse gas emissions. The state can achieve a goal of reducing demand for petroleum fuel to 15 percent below 2003 levels by 2020 while continuing to meet the demand for transportation services.

EFFICIENT, ENVIRONMENTALLY SOUND AND DIVERSE TRANSPORTATION ENERGY SYSTEM

Continued reliance on petroleum-based fuels poses risks for the economic and environmental health of California. With in-state refineries operating at near capacity, efforts are needed to improve near-term supply responsiveness when refineries experience unplanned outages. Over the long-term, the state should work to reduce demand for petroleum and shift to a more efficient, environmentally sound and diverse transportation energy system. Options to address our fragile supply and demand condition include an increased supply of non-petroleum fuels as well as lessening fuel demand. Although these solutions are mid- to long-term, action should be taken now to avoid the adverse consequences related to California's heavy reliance on petroleum.

From the mid-1970s through the late 1980s, significant gains in the fuel economy of passenger vehicles were made, primarily to meet federally mandated CAFE standards. Since then, CAFE standards have remained virtually unchanged and technology advancements for passenger vehicles have been employed primarily to improve safety, performance, and comfort rather than boosting fuel economy.[27]

While passenger vehicle fuel economy has remained relatively flat in the last two decades, California's petroleum demand has risen substantially. This trend has been primarily due to three factors: increasing miles traveled per vehicle, a rising state population, and growth in the sales of less fuel-efficient vehicles, including SUVs and other light trucks.

Other potentially significant trends may allow for higher passenger vehicle fuel economy. For example, gasoline hybrid electric vehicles and light-duty diesel vehicles offer efficiencies much higher than conventional gasoline vehicles. In addition, future state actions to address global climate change and greenhouse gas emissions could lead to reductions in the demand for petroleum fuels in the transportation sector.

To reduce California's dependence on petroleum, measures must be adopted to improve transportation efficiency and expand the use of non-petroleum fuels. Just as the state's substantial demand for petroleum products is the result of many factors that have occurred over a long period of time, efforts to reduce petroleum consumption will require implementation of a suite of options over the long term. While there are steps that the government can take in the near term, the most effective strategies to reduce demand for petroleum require long lead times to fully implement.

Several categories of options exist to ease California's growing demand for transportation fuels:

1. Increase fuel efficiency of existing vehicles
2. Increase fuel efficiency of new vehicles
3. Fuel substitution options
4. Pricing options
5. Other options

The measures considered here can be part of a "portfolio approach," a method of pursuing a suite of options to hedge against supply concerns and volatile fuel prices. Over time, these and other options can be applied to help ensure California's transportation system remains secure, cost effective and environmentally benign.

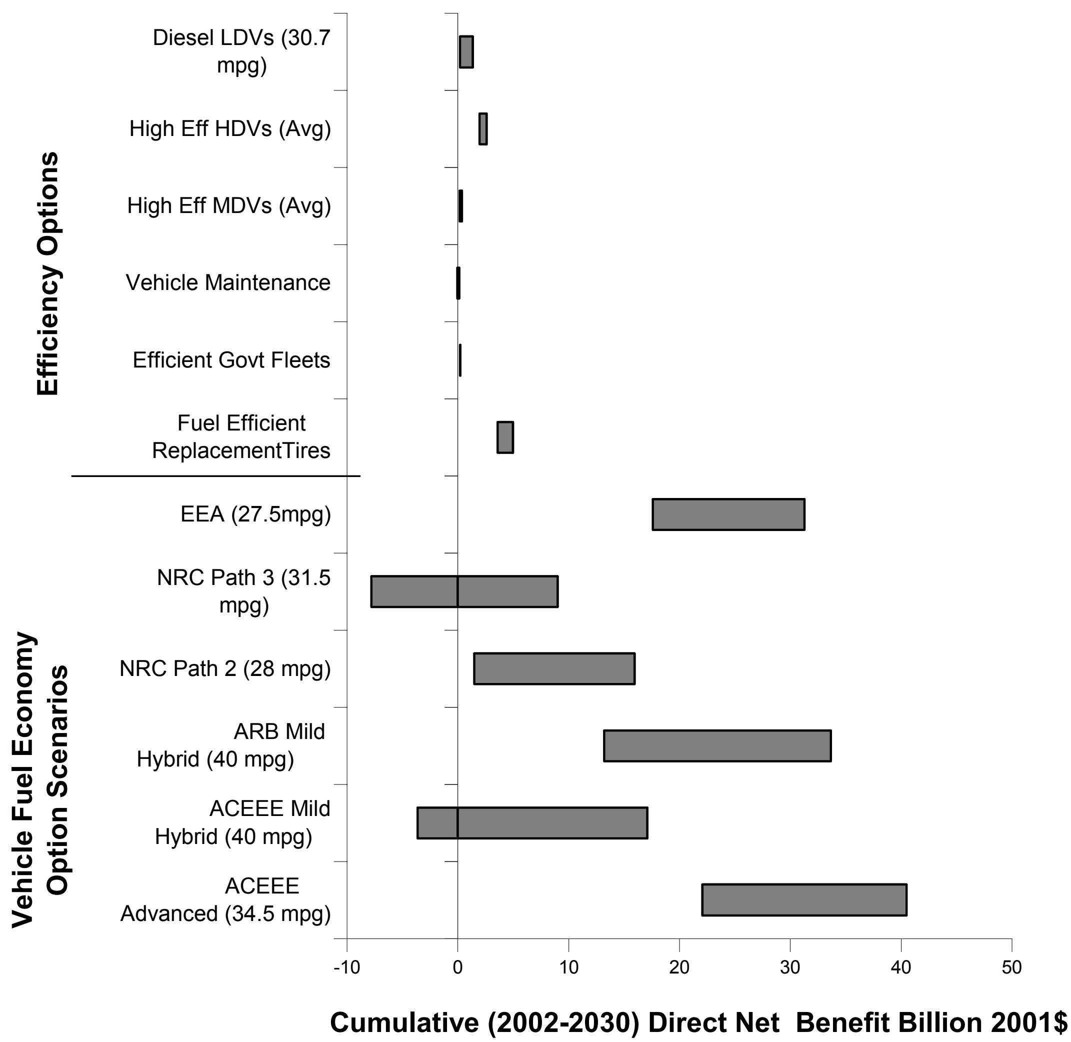
COSTS AND BENEFITS EVALUATION OF MEASURES TO REDUCE PETROLEUM DEPENDENCE

Petroleum Dependence Reduction Measures

The Energy Commission and the CARB recently completed a report titled: ***Reducing California's Petroleum Dependence*** in response to AB 2076. In part, this legislation directed the Energy Commission and CARB to develop and adopt recommendations for the Governor and the Legislature on a strategy to reduce California's petroleum dependence. As part of this effort, petroleum reduction options were evaluated based on a comparative cost and benefit methodology. This work, which includes estimates of the net benefits to the state from various transportation options, considered consumer and economic costs, environmental benefits, and the external costs of petroleum dependence.

Based on the analysis conducted for the AB 2076 report, **Figures 7-1 and 7-2** show the estimated range of direct net benefits (in billions of 2001 dollars) for California during the time period 2002 to 2030 for most of the options considered. Direct net benefits include the impacts on consumers, the environment, and energy security.

Figure 7-1
Direct Net Benefit of
Selected Fuel Efficiency Options and Scenarios



* Vehicle Fuel Economy Option Scenarios are based upon 100% market penetration by 2014; others vary.

Analyses for the fuel efficiency options, in general, assumed 100 percent penetration of various fuel economy technologies for new vehicles. In contrast, analyses for most of the fuel substitution options were based on a fixed market penetration level during the time period in an effort to provide reasonable fuel-by-fuel comparison.

These assumptions are not intended to be forecast estimates of fuel use or technology acceptance. Assumptions were made to estimate the potential advancements with technologies, with the general assumption that the greatest advancements would be made with emerging technologies.

Improvements in Vehicle Fuel Efficiency

Several methods can be employed to improve the fuel efficiency of new and existing vehicles. Listed below are highlighted options analyzed in the AB 2076 report.

Fuel Efficient Tires and Proper Tire Inflation

Research has shown that a vehicle's fuel economy can increase or decrease depending on the rolling resistance of its tires. The potential fuel economy improvement from low rolling resistance tires is approximately three percent compared to tires with average rolling resistance.[28] While low rolling resistance tires can provide important and cost effective fuel savings, little information is available on fuel efficiency of various replacement tires, both to researchers outside the tire industry and consumers. As a result, more information must first be collected and analyzed on rolling resistance before the full efficiency benefits can be determined. Once this is completed, an outreach program to disseminate this information to consumers could provide significant fuel savings.

According to the Rubber Manufacturers Association, a typical passenger vehicle will suffer an approximately one percent reduction in fuel efficiency from under-inflated tires.[29] When tires are grossly under inflated, fuel economy can be reduced by several percentage points. Numerous studies have shown that when tires are under-inflated, vehicle safety is impaired and tire wear is increased. A consumer outreach program, designed to inform and encourage consumers to maintain proper tire pressure, could provide substantial savings of fuel over time.

Improved Vehicle Maintenance

This option would initiate a state campaign to educate motorists on the benefits of improved maintenance practices as a way of reducing gasoline consumption. Improving the efficiency of California's vehicle population through better maintenance can be achieved immediately since it does not require technology advancement. Better vehicle maintenance may include periodic engine tune-ups, improved engine lubrication, changes of air and oil filters, and other maintenance measures. The United States Department of Energy (U.S. DOE) estimates that failure to perform periodic maintenance practices can reduce individual vehicle fuel economy by 1 to 10 percent in the case of air filter changes and by one to two percent in the case of oil and oil filter changes.

Efficient Government Light-Duty Fleets

This petroleum reduction option would direct government fleet vehicles in California to use more fuel efficient vehicles or vehicles that use non-petroleum fuels. Under this option, local, state, and federal fleets would select the most fuel-efficient vehicle in each class for their vehicle purchases whenever service requirements can be safely satisfied. Currently, there are about 231,000 light-duty vehicles in government fleets in California; approximately 41,000 of those are in the state's fleet.[30] Analysis shows approximately seven million gallons of petroleum could be reduced each year from implementing this option.

Efficient Diesel

Currently produced light-duty diesel vehicles are typically 30-60 percent more fuel efficient[31] than comparable gasoline vehicles. Therefore, an increased sales penetration by these vehicles could reduce petroleum use in the state. National requirements for improved diesel fuel formulations that lower sulfur levels to 15 ppm in late-2006 and further development of emission control systems tailored to diesel engines may allow greater use of light-duty diesel vehicles in the U.S. While manufacturers have not yet fully demonstrated that they can build cost-competitive diesel cars and light-duty trucks that meet California's emission standards, the potential exists for diesel passenger vehicles to significantly penetrate the light-duty vehicle fleet in the next decade and beyond.

The vast majority of heavy-duty trucks and buses run on diesel, as do a significant portion of medium-duty vehicles. The potential exists to boost medium- and heavy-duty diesel fuel efficiency through research, development, and demonstration (RD&D) programs, such as the U.S. DOE 21st Century Truck Program, a government and private industry collaborative.

Truck and bus fuel economy gains used as an upper bound in the AB 2076 analysis are based on the 21st Century Truck Program goal of doubling fuel economy. The technology improvements explored in this effort include better combustion technology, reductions in vehicle weight, the use of hybrid and auxiliary power technologies, aerodynamic improvements, and rolling and inertia resistance improvements.[32]

Truck Stop Electrification

Although truck stop electrification was not one of the AB 2076 options analyzed, it offers opportunity to improve energy use and reduce emissions at truck stops. Approximately three[33] to seven[34] percent of the on-road diesel demand in California. Further, more than 10,000 tons of regulated and unregulated emissions are generated due to truck idling in the state.[35]

Truck drivers idle their engines while the vehicles are at rest in compliance with federal regulations or as they wait to load at distribution centers, port facilities or transfer stations. Because long haul truckers need power to heat and cool the tractor cabin and ancillary electricity to run cabin devices, drivers traditionally let their diesel engines operate while parked. As a result, this inefficient process to maintain cab comfort and provide power to appliances in the truck consumes fuel and produces additional diesel emissions. Both on-board and off-board technologies are available to reduce truck idle-related fuel consumption and emissions. These include truck stop electrification and the use of auxiliary power units.

One form of truck stop electrification infrastructure is facilities equipped with air conditioning installed on a truss over parking spaces. Hoses connected to the air conditioning units deliver warm or cool air to the cab of parked trucks for an hourly fee of $1.25 to $1.50.[36] This allows drivers to turn off their engines, thereby saving fuel, reducing emissions and lessening engine wear. The basic heating and cooling services are augmented with internet access, commercial, cable and educational programming and electricity supply. No modification of the truck is required. A window template, currently priced at $10, allows the service module hose to be connected to the tractor cabin. California truck stops at Bakersfield, Ripon, Lost Hills and Santa Nella have been operating this type of truck stop electrification infrastructure.

Another form of truck stop electrification, Shore Power, is an idling reduction strategy that provides electricity to trucks equipped with electrical appliances, such as air conditioners, heaters and refrigerators. Trucks are also equipped with backup batteries for use when the trucks are not at a truck stop. An upgraded alternator assists in recharging the battery. Since many trucks are not equipped with appliances that run on electricity, retrofitting is required for using Shore Power. The Sacramento Municipal Utility District is demonstrating a Shore Power application in Sacramento, California.

Auxiliary power units (APU) can also provide needed power to trucks using generators powered by small internal combustion engines or fuel cells. The Pony Pack is an example of an internal combustion APU that is available to drivers today. However, the fuel cell technology needed for an APU requires additional development and the establishment of a fueling infrastructure. The capital cost associated with available and emerging APUs will tend to limit their widespread use in the truck fleet in the near term.

Hybrid Electric Vehicles

The introduction of gasoline-electric hybrid vehicles (hybrids) in the late 1990s marked the beginning of a significant change in vehicle platforms and the potential to provide important fuel economy improvements. Hybrid vehicles commercially available today utilize both a small internal combustion gasoline engine, an electric motor and a bank of batteries to maximize fuel economy, while producing very low tailpipe emissions.

While only three models of commercial hybrids have been introduced to date, several automakers have announced plans for additional models in the next few years. Furthermore, some manufacturers see this technology becoming mainstream in a few years, and found in most light-duty models.

> (Toyota)…executives pledged that Toyota's hybrid technology will work its way into almost every Toyota and Lexus nameplate in the near future, either as a fuel-economy measure or for higher performance.[37]

Hybrid vehicles can be designed in various configurations, including mild or full-hybrids, which are distinguished by the amount of power provided by electricity.

An emerging variation of the hybrid vehicles is the grid-connected or plug-in hybrid. This type of hybrid compared to the non-grid-connected hybrid typically has a larger electric motor, can have a smaller internal combustion engine and can be plugged in to recharge a larger bank of batteries. These features allow grid-connected hybrids to operate on batteries alone for a portion of their travel. Although the technology can cover a full range of battery-alone-operation, the distance proposed by developers is typically 20 to 60 miles. The portion of trips in excess of the battery range is served by the internal combustion engine and electric drive combination. Since a majority of daily vehicle trips are less than 60 miles in length, grid-connected hybrids with appropriately sized battery packs can replace at least half of all gasoline powered vehicle trips.[38]

In addition to greater reduction of petroleum use, the key environmental advantage offered by a grid-connected hybrid compared to a non-grid-connected hybrid is its reduced tailpipe emissions over its life cycle. Emission regulations adopted by the CARB for zero emission vehicles recognizes the reduction offered by grid-connected hybrids. This action may encourage greater automotive manufacturer interest in commercializing this type of technology.

The component with the largest impact on incremental cost for grid-connected hybrids is the battery. The CARB's Advanced Battery Panel expects the per vehicle cost of batteries to be in the range of $13,000 to $20,000 in production quantities of 100,000 units per year, declining to about $7,000 per vehicle with additional research and development and greater production volumes.[39]

Grid-connected hybrid technology is the subject of research linked to the improved operation of electric grid systems. The Electric Power Research Institute[40] and the University of Delaware[41] are evaluating this technology for its potential to serve as a distributed generation option, producing electricity when at rest. A form of ancillary services called "regulation services" shows particularly strong potential for being served by grid-connected hybrids. If they choose to do so, vehicle owners could sell such a service to electricity providers.

Increasing Fuel Economy Standards

According to some national experts, such as the National Research Council of the National Academy of Sciences and the American Council for an Energy Efficient Economy, multiple pathways exist to achieve an on-road fleet average fuel economy of 30 to 45 miles per gallon (mpg). The CAFE standards, set by the federal government beginning in 1977 and virtually unchanged since 1985, require a fleet average of 20.7 mpg for light-duty trucks and 27.5 mpg for passenger cars. Thus, there appears to be a significant opportunity to reduce petroleum fuel consumption by increasing the fuel economy of light-duty vehicles.

In most of the fuel economy scenarios evaluated in the AB 2076 report, increasing vehicle fuel economy provides consumer life cycle fuel savings that exceed the increased cost of the more fuel-efficient vehicle.[42] A combination of technology options available to automakers could yield a doubling of average fuel economy to approximately 40 mpg in a cost-effective manner.

The technologies examined for achieving fuel economy improvement in the AB 2076 report have in general been sufficiently developed to warrant their consideration for widespread application. These technologies include improved aerodynamics, increased use of low rolling resistance tires, integrated starter-generators with 42 volt electrical systems, continuously variable transmissions, and hybrid-electric designs. Engine efficiency improvements through variable valve timing, cylinder deactivation, and direct injection fuel systems can also be employed utilizing technology that is now available.

The idea of government-imposed fuel economy standards has been challenged by some, who have called them unnecessary in a free market system. In theory, more fuel efficient vehicles would be produced if buyers demanded them, making minimum fuel economy standards unwarranted.

Although a valid economic argument, it is not necessarily applicable in this case. First, this result can only be assured in the case of "perfect" competition.[43] With imperfect competition, of which the auto industry is an example, there is no guarantee that the market would be so responsive to consumers. Theoretical work on imperfect competition has shown that it can lead to market failures—in the form of a less than optimal variety and/or quality of goods.[44] Therefore, it is very possible that the optimal fuel efficiency from the point of view of new car buyers is higher than the levels that are currently being provided.

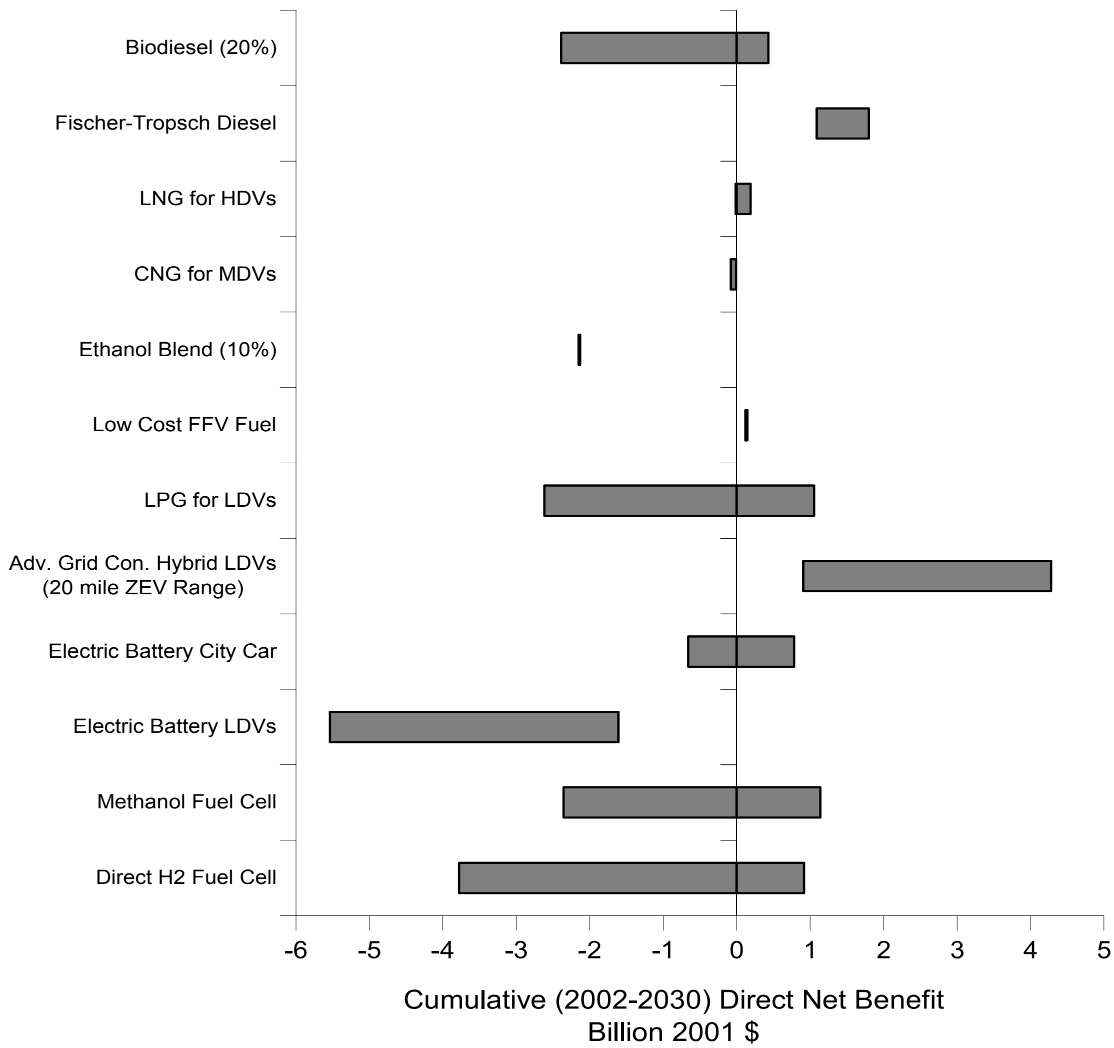
Second, used vehicle buyers do not necessarily have the same preferences. Since those who typically buy used cars have lower income on average than new car buyers, it can be expected that fuel efficiency would be more important for used car buyers. The analysis for AB 2076 implicitly includes both new and used car buyers by assuming a 15-year payback period for fuel efficiency technologies.

Fuel Substitutions/Alternative Fuels

In addition to demand reduction options such as improved efficiency, supply-side options are available. This would include expanded use of cleaner burning, non-petroleum fuels, often referred to as alternative fuels.

Since the late 1970s, the state has investigated and promoted the use of non-petroleum fuels. Penetration of these fuels into the California market has been limited, and their usage continues to be small compared to petroleum-based fuels. Furthermore, while gasoline and diesel are readily available throughout the state, the availability of non-petroleum fuels is much more limited. Below is a summary of the status and availability of several advanced technologies and alternative fuels. **Figure 7-2** illustrates the estimated direct net benefits of several of these highlighted petroleum substitution options that were analyzed as part of the AB 2076 report.

Figure 7-2
Direct Net Benefit of
Selected Fuel Substitution Options



Ethanol

Ethanol can also be used in flexible fuel vehicles (FFVs) that can operate on a mixture of up to 85 percent ethanol and 15 percent gasoline, called E85. Since 1998, approximately 200,000 ethanol FFVs have been sold in California. With no E85 available in the state until recently, these vehicles have thus far been operated on gasoline only. California's first E85 station recently began operation in San Diego, one of about 160 E85 stations operating in 25 different states, about half of these in Minnesota. Several additional E85 fueling installations are being undertaken by state and federal government fleets in California.

The current production of FFVs by the Big Three U.S. auto makers is the result of 1998 federal legislation that gives manufacturers credits toward their CAFE compliance for production of alternative fuel vehicles, including partial credit for dual-fuel or flexible fuel vehicles. Maximum application of the credit for FFVs, which is currently authorized through 2004, could increase a manufacturer's CAFE compliance calculation up to a "cap" of 1.2 mpg. NHTSA, the federal agency responsible for implementation of this credit, is presently recommending that Congress extend the credits through 2008, with a reduction of the cap to 0.9 mpg. The NHTSA analysis in support of its recommendation concludes that there is value to domestic energy security of having a fleet of vehicles capable of operating on non-petroleum fuels and that four additional years of the credit program is the minimum period necessary to begin the establishment of the fueling infrastructure necessary to realize the potential benefits of such a fleet.

The U.S. ethanol industry, which uses corn as the primary feedstock, is in the midst of a major expansion that will triple its 2001 output by 2005, when about five billion gallons per year of production capacity will be in place. California is expected to join the ranks of states with major ethanol production facilities, with several projects using both corn and sugar cane feedstocks presently in the advanced planning stages. Continued progress in the development of biomass-to-ethanol process technologies that can use various agricultural, forestry and municipal wastes and residues will increase the potential for renewable ethanol production with additional environmental and economic benefits.

Methanol

Automobile manufacturers have in the past produced FFVs designed to operate on M85, a blend of 85 percent methanol and 15 percent gasoline. Several thousand of these vehicles were commercially introduced in California between 1992 and 1998. However, the use of M85 was discontinued after the last of the agreements expired between fueling stations and the state. The fuel is no longer distributed in California. At its peak, there were approximately 100 stations dispensing M85 in the state.

Methanol is often described as an excellent "hydrogen carrier" and is being used as a demonstration fuel for a few prototype fuel cell vehicles (FCVs). Indirect methanol FCVs use a reformer to extract hydrogen from pure methanol. Analysis conducted by staff as part of the AB 2076 report only considered a scenario where methanol would be used in FCVs (Figure 7-2). One methanol FCV is known to have been demonstrated in California. A methanol station in West Sacramento provides fuel for methanol fuel cell vehicles located at the California Fuel Cell Partnership's facility. There appear to be no plans to add methanol stations in the state, and its future market acceptance remains unclear.

Fischer-Tropsch Diesel

Fischer-Tropsch diesel is a synthetic fuel made from natural gas, coal or biomass feedstocks. Often referred to as a gas-to-liquids process, recent Fischer-Tropsch diesel projects emphasize the use of remote sources of natural gas. The Fischer-Tropsch process can be used to make a variety of synthetic fuels, including gasoline and alcohols, although diesel is currently the preferred end product. Fischer-Tropsch diesel can be used either alone or blended with conventional diesel and its use does not require modification to conventional compression ignition (diesel) engines or existing fueling infrastructure.

Because pure Fischer-Tropsch diesel has a high cetane number, low aromatic content and no sulfur, it is attractive for blending with conventional diesel. Stringent diesel exhaust emission standards and fuel specifications are causing the petroleum industry to reconsider new and improved gas-to-liquids processes to competitively produce aromatic, cetane, and sulfur complying diesel fuel.[45]

Converting remote sources of natural gas to a liquid provides an opportunity to expand the use of such resources. These resources are located where there is little or no demand for the gas and transporting the gas to demand centers makes it prohibitively expensive. Thus, remote gas has a relatively low value. Converting the gas to a liquid fuel increases its value and the cost to transport the fuel is less per unit of delivered energy. For these reasons and other factors some remote natural gas can now be economically converted into Fischer-Tropsch diesel.

Although current development projects for Fischer-Tropsch diesel have focused on remote natural gas feedstocks, the Fischer-Tropsch process can produce similar quality liquid fuels from other hydrocarbon feedstocks like coal and biomass. By adding a gasification step in the conversion process, a synthesis gas can be made from these hydrocarbon feedstocks. U.S. DOE has a project to develop and demonstrate the synthesis of alternative transportation fuels and chemicals from such feedstocks.[46]

While the development and use of coal resources in the U.S. faces many environmental and land use challenges, it represents the nation's largest energy resource. By one estimate, this resource has the potential to produce up to 20 trillion gallons of Fischer-Tropsch diesel.[47]

One of the key environmental issues related to the production of Fischer-Tropsch diesel using coal versus natural gas is its comparatively greater emission of CO_2, an important greenhouse gas. Without the use of sequestration technology, a plant using the Fischer-Tropsch process with coal feedstock would increase CO_2 emissions per unit of energy output by a factor of 2.6 compared to a natural gas feedstock.[48] On the other hand, sequestration in the coal case reduces its CO_2 impact to about 60 percent of the natural gas case.

Although large volumes of Fischer-Tropsch diesel are not currently being used in California, Shell sold over one million gallons of Fischer-Tropsch fuel (middle distillate) to four California refiners over the period of November 1993 to December 1997. The Fischer-Tropsch fuel was blended into conventional diesel fuel. California's Department of Transportation is currently using Fischer-Tropsch diesel fuel in limited trials. The requirement for ultra-low sulfur diesel beginning in late 2006 may increase the value of Fischer-Tropsch diesel and increase its use to produce a CARB diesel formulation.

Interest in gas-to-liquids or Fischer-Tropsch facilities is worldwide. Large scale facilities have been built by Mossgas and Sasol in South Africa and Shell in Malaysia. Chevron Texaco and Sasol have developed a partnership to build gas-to-liquids plants using a specific gas reforming technology.[49] Pilot or demonstration scale facilities operated by Exxon Mobil in Louisiana and BP in Alaska have begun testing various gas-to-liquids processes and hardware configurations.[50] A pilot facility is also being constructed by Conoco Phillips in Oklahoma.[51]

Capital costs for Fischer-Tropsch plant construction is higher than conventional diesel production facilities.[52] To compete successfully with traditional diesel fuel, the Fischer-Tropsch process needs low-cost feedstocks at less than $1 per million British thermal units (Btu). Fischer-Tropsch diesel produced from pipeline supplied natural gas would not be competitive due to the high value of pipeline-supplied natural gas. A proponent for a coal-based Fischer-Tropsch process reports that western U.S. coal could be secured for less than $1 per million Btu.[53]

Biodiesel

Biodiesel is a renewable diesel replacement fuel made from new and used vegetable oils and animal fats that are chemically reacted with an alcohol to produce fatty acid methyl esters. Biodiesel is the name given to these esters when used as a fuel. Little or no modification to an engine is required with biodiesel/diesel blends. Different concentrations of biodiesel fuels have been used in vehicles, ranging from two percent blends with conventional petroleum diesel (B2) to neat biodiesel (B100). Current marketing of biodiesel focuses on B2, B5, and B20 blends.

According to the U.S. DOE a majority of biodiesel producers can use any fat or oil feedstock to make biodiesel.[54] The balance of the industry uses vegetable oils, the least expensive of which is soy oil. Although soybeans are not a significant agricultural commodity in California, there is increasing interest for in-state biodiesel production using recycled cooking grease (yellow grease), fat from animal rendering facilities, and oils from other renewable feedstocks. According to American Bio-Fuels and Hondo Chemical Inc., their joint venture to build a biodiesel facility in Bakersfield should begin operation in October 2003.[55] The facility will initially be able to produce 2.5 million gallons, which may grow to 35 million gallons annually. Another facility in Coachella, California, has an annual capacity of 10 million gallons.[56]

Approximately four million gallons of biodiesel were consumed in California during 2002.[57] The City of Berkeley announced in June 2003, that it is converting its fleet of almost 200 diesel vehicles to operate on 100 percent biodiesel (B100). The National Biodiesel Board reports that in 2002 more than 15 million gallons of petroleum diesel was displaced by biodiesel in the U.S.[58]

The retail cost of biodiesel fuels depends on various factors, including the cost of the original feedstock, state and federal subsidies, taxes, transport and delivery costs, and retail margins. On a volumetric basis, the cost of biodiesel fuels is generally higher than conventional diesel. From survey data reported by the U.S. DOE[59], the average differential price between B20 and conventional diesel on the West Coast varied between $0.21 (October 2002) to $0.41 (July 2002) per gallon.

In national energy policy legislation, the U.S. Senate has adopted a bill with a production incentive of up to $1.00 per gallon for certain types of biodiesel (e.g., soybean-based B100). If this provision becomes law, a portion of this incentive may be used by producers to nullify the current price differential between biodiesel and conventional diesel fuel.

Biodiesel use can result in the reduction of several criteria pollutants, depending on engine type, fuel quality and other blend stocks, and the feedstock used to produce the fuel. From a national database of emission tests conducted prior to October 2002, U.S. EPA has attempted to project average emission impacts of biodiesel for heavy-duty highway engines.[60] Compared to an average diesel fuel, a soybean-based B20 fuel would reduce emissions of particulate matter, hydrocarbons, and carbon dioxide. However, this fuel slightly increased nitrogen oxide (NO_x) emissions.

Although analysis presented in the Energy Commission's report for reducing California's petroleum dependence showed a decrease in life cycle emissions of greenhouse gases for soybean-based biodiesel,[61] testimony at an Energy Commission workshop raises important issues regarding the basis for this earlier work and presents an alternative conclusion[62].

Natural Gas

Natural gas continues to be used as a transportation fuel in California in a variety of light- and heavy-duty vehicles. In applications where vehicle range is critical, liquefied natural gas (LNG) is preferred over CNG. Natural gas vehicles (NGVs) have emerged in a variety of on-road applications and are designed as either bi-fuel or dedicated (natural gas only) vehicles.

For the 2003 model year, three automobile manufacturers each offered CNG passenger models for sale and two manufacturers offered a total of five light trucks and vans.[63] Among medium- and heavy-duty vehicle classes, vehicles now offered include refuse haulers, street sweepers, transit and school buses, transit shuttles, trolleys, and large vans. Heavy-duty engine manufacturers such as Caterpillar, Cummins, Detroit Diesel, and John Deere produce a number of different engine models designed for natural gas.[64] These engines can be used in new trucks or in re-powered vehicles.

Based on data compiled by the Department of Motor Vehicles, about 25,600 passenger cars and light-duty trucks are now registered as natural gas capable. In the medium- and heavy-duty vehicle classes, there are about 4,350 natural gas vehicles dominated by heavy-duty transit buses which number more than 3,900.

The amount of natural gas annually used in California for transportation is estimated to be about 59 to 67 million gallons gasoline equivalent, of which, 70 to 80 percent is consumed by medium- and heavy-duty vehicles.[65]

For a number of factors, NGVs currently cost more than their gasoline and diesel counterparts. For light- and medium-duty CNG vehicles compared to gasoline vehicles the incremental cost ranges from about $4,500 to $6,000.[66] The incremental cost for LNG and CNG transit buses is estimated to be about $40,000 and $49,500, respectively.[67]

For light- and medium-duty vehicle classes the higher cost is due primarily to the purchase and installation of the on-board fuel-storage systems. For heavy-duty vehicles the higher cost is a combination of greater expense for the engines and the on-board fuel storage systems. Current heavy-duty engine price premiums are largely due to low manufacturing volumes. One engine manufacturer has indicated that its cost of commercially available heavy-duty natural gas engines could cost less than their diesel counterparts if sold at equivalent volumes.[68]

Although heavy-duty NGVs cost more than their diesel counterparts, most use engines that are certified to one of the state's Optional Low-NO_x Emission Credit Standards. Due to this low emission characteristic, fleets have been eligible to receive incentive funds from various clean air programs to offset the higher capital costs of these engines.

Traditionally, natural gas prices have been lower than diesel and gasoline on an energy equivalent basis, which can offset higher vehicle capital costs. However, retail fuel prices vary depending on the cost of natural gas in the specific utility service area, bulk or retail purchase arrangements and fuel facility throughput volumes.

A mix of natural gas fueling stations is beginning to form a reliable and potentially sustainable infrastructure in California. These facilities may dispense CNG, LNG, or both. In 2003, about 200 CNG stations are operating in the state with approximately 80 of this total providing public access.[69] In addition, home fueling appliances can also be purchased to slow fill vehicles at home or in fleets.

Liquefied Petroleum Gas

Liquefied Petroleum Gas (LPG), or propane, continues to be used as a transportation fuel. Like natural gas vehicles, LPG vehicles are generally produced as bi-fuel designs, allowing the operator to run on LPG or gasoline. LPG vehicles operating in the state number in the thousands. As in recent years, only a few vehicle models have been available for sale in California.

Approximately 1200 LPG stations can be found in California. However, the majority are used for purposes other than transportation, with only about 3 percent of these stations providing fuel for vehicles.[40]

Electricity

California has been a leader in the use of electric vehicles primarily because of the zero emission vehicle regulation adopted by the CARB. Originally implemented in 1990, the CARB has made periodic modifications to their zero emission vehicle rule, including recent changes made in April 2003. These changes provide the automakers greater flexibility in meeting the zero emission vehicle rule and now include options to use ultra low emission technologies and an option to produce hydrogen fuel cell vehicles or battery electric vehicles.

The number of electric vehicles operating on California roadways has decreased in recent years. As of mid 2003, the number of electric vehicles in California is estimated at a few thousand, including neighborhood electric vehicles. With the current market and regulatory environment, it is doubtful whether battery electric vehicles will achieve widespread use.

While the current market and regulatory environment makes successful penetration of on-road electric vehicles uncertain, neighborhood electric vehicles continue to be sold in the state and now substantially outnumber full-size, passenger electric vehicles. Unlike full-size electric vehicles, which generally recharge at high voltage, neighborhood electric vehicles are often charged at home or at work using conventional 110 volt electrical outlets and are restricted from highway use.

A significant electric vehicle market is in non-road applications. Non-road electric vehicles include forklifts, airline ground support equipment (i.e., baggage handlers) golf carts, sweepers and others. In 2002, these vehicles had an estimated load of more than 800 megawatts of power in California.[70]

Compared with internal combustion-powered industrial vehicles, battery-powered units can provide the following advantages: zero in-plant emissions, the potential for lower total life cycle costs, reduced noise and vibration, and reduced potential for fluid leaks.[71] Like their on-road counterparts, electric vehicles can be attractive to electric utility companies if vehicles are charged during off-peak periods, enabling them to better manage their electricity load. The drawbacks of electric non-road vehicles include generally higher capital cost, slow recharging time, need for charging equipment and the need to replace or recondition batteries periodically.[72]

Hydrogen

Significant resources are being devoted to hydrogen fuel cell vehicles (FCVs) by most automakers and technology advancements have been encouraging. Substantial barriers still exist before a commercially viable product can be produced. Automakers now demonstrating FCVs have predominately chosen hydrogen as their fuel of choice, negating the need for an integrated on-board reformer in the near-term. Hydrogen to fuel internal combustion engines is also being demonstrated by some automakers.

In his 2003 State of the Union address, President Bush announced a $1.2 billion initiative to develop commercially viable hydrogen-powered fuel cells to reduce the nation's growing dependence on foreign oil. This initiative recognizes that a hydrogen-fueled transportation sector needs much larger volumes of hydrogen than currently produced and that the costs of producing, delivering, and storing hydrogen must be reduced.[73] Processes being evaluated and developed by the U.S. DOE include new technologies to simplify the production of hydrogen from natural gas and related capture of carbon dioxide. Hydrogen production is also being pursued in combination with coal gasification facilities that co-produce electric power and other high-value fuels and chemicals.

The Hydrogen Fuel Initiative can be combined with existing federal activity under the FreedomCAR (Cooperative Automotive Research) Partnership that focuses on vehicle fuel cells and hydrogen infrastructure technologies.[74] The FreedomCAR Partnership involves the U.S. DOE, DaimlerChrysler, Ford, and General Motors. The automotive companies form the

U.S. Council for Automotive Research. The Partnership's goals are broad in scope, targeting technologies like fuels cells that can lead to less petroleum use and lower criteria and carbon emissions on a life-cycle and well-to-wheel basis.

The California Fuel Cell Partnership is working to help commercialize fuel cell vehicles through a public/private effort. Activities include demonstrations of fuel cell vehicles and development of necessary fueling infrastructure. Although the fuel-related work of the California Fuel Cell Partnership is not directed toward hydrogen exclusively, the majority of this effort has been aimed at hydrogen because of the added complexity on-board fuel reformers pose for other fuels. Hydrogen work by the California Fuel Cell Partnership includes training emergency responders on hydrogen safety, monitoring and participating on codes and standards setting committees, establishing fueling stations, researching hydrogen-safe facilities (such as maintenance facilities and parking garages), educating the public on hydrogen fuel and other related efforts.

Given the interest on the part of automotive manufacturers, the deployment of hydrogen fueling stations is a growing consideration. Hydrogen infrastructure will likely be limited in the near term by high capital investment costs, as well as the very limited number of demonstration vehicles that will be available to use the fuel in the next few years.

Summary of Clean-burning Fuel Use in California

Table 7-1 summarizes the status and availability of various clean-burning fuels and their use in California. FFVs have the largest number of clean-burning fuel vehicles, which the automakers produced and sold to the private market. The automakers produced these vehicles as a result of federal legislation giving automakers credits toward their CAFE compliance for producing clean-burning fuel vehicles that can use alternative fuels. The other vehicle types use the most alternative fuels. These vehicle types typically operate in captive fleets.

The use of captive or centralized fleets has long been an effective method for introducing new fuels and vehicle technologies into the marketplace. Since the initial development and introduction of "alternative fuel" vehicle technologies in the early 1980s, the method of using fleets has served to ease the transition for all parties involved: automakers, alternative fuel providers and the fleets involved in the demonstrations. The benefits of utilizing fleets are several and include the following:

1. Fleets may benefit by paying less for ordering many vehicles.
2. Fleets central vehicle maintenance facilities provide better opportunity for close monitoring and testing new technologies.
3. Alternative fuel providers and fleets benefit by concentrating fueling infrastructure in one location, where fuel quality and usage is more easily tracked.
4. Centralized fueling can be much less costly than dispersed sites.

Table 7-1
Clean Burning Fuel Use in California

Fuel Type/Technology	Estimated Use, Million Gallons/Year (gasoline gallon equivalent)	Estimated Number of Stations in California	Estimated Number of Vehicles in California
Ethanol/FFVs (E85)	0	0	200,000
Methanol/FFVs (M85)	0	0	5,600
Methanol/Demonstration Fuel Cell Vehicle (M100)	NA	1	1
Fischer-Tropsch Diesel	NA	0	NA
Biodiesel	4.3(1)	NA	NA
Compressed Natural Gas	52-60	206	30,000(2)
Liquefied Natural Gas	6.5(3)	25	575
Liquefied Petroleum Gas	NA	35	2,400(4)
Electricity, (Including neighborhood vehicles)	1.7(5)	Hundreds	12,500
Hydrogen/Demonstration Fuel Cell Vehicles	NA	8	15

(1) Based on 4 million actual gallons, California Energy Commission memo, Scott Hughes, National Biodiesel Board; assumes 120,000btu/gallon, 2002
(2) California Department of Motor Vehicles Data, 2003
(3) Based on 10 million gallons of LNG, Jon Leonard, Personal communication, TIAX, LLC
(4) Gary Occhiuzzo, California Energy Commission
(5) Year 2000, based on 540 million kWhr; Commission Energy Commission, *Reducing California's Petroleum Dependence*; *Appendix B*, 2003

In addition, hybrid electric vehicles (hybrids) are emerging rapidly in the market. The introduction of new transportation technologies which use the existing fueling infrastructure, such as hybrids, can also benefit from early introduction into fleets. Automakers can more easily monitor and control the use of new technologies in fleets as they can receive an "early warning" of problematic vehicle components and systems prior to the release into the public.

Federal and state government fleets, as well as fleets owned by alternative fuel providers such as electricity and gas utility companies, are required to purchase alternative fuel vehicles under the Energy Policy Act of 1992 (EPACT). EPACT fleet purchase requirements, over time, have increased to 75 percent of non-exempt light-duty fleet purchases. Exempt vehicles include law enforcement and emergency vehicles, non-road vehicles, vehicles held for lease or rental to the general public, vehicles held for sale by dealers and military vehicles.[75] These requirements were included to stimulate the production and use of non-petroleum fuels and light-duty vehicles capable of operating on them. Fleets covered under the EPACT rule may use a variety of covered fuels and alternative fuel vehicles.

Pricing Options

Pricing strategies can also be used to reduce California's petroleum dependence. The pricing options shown in **Table 7-2** could contribute to reduced gasoline use through their effect on consumer behavior. However, some of the pricing options did not yield positive net benefits for consumers while the remaining pricing options were politically impractical.

- Gasoline Tax
- "Pay at the Pump"
- "Pay as you Drive"
- Tax on Vehicle Miles Traveled
- Feebates
- Registration Fee Transfer
- Purchase Incentives

Table 7-2
Description of Pricing Options Evaluated

Option	Description
Gasoline Tax	Raise California gasoline tax by $0.50 per gallon.
Marginal Pricing for Auto Insurance "Pay at the Pump"	A portion of motorists automobile insurance would be paid through a fuel surcharge.
Marginal Pricing for Auto Insurance "Pay as you Drive"	A portion of automobile insurance would be paid through a per-mile charge.
Tax on Vehicle Miles Traveled	A tax on VMT in California of 2 cents per mile.
Feebates	Purchasers of new vehicles either receive a rebate if they buy vehicles emitting relatively low levels of carbon(a) or pay a fee if they buy a vehicle that emits relatively high levels of carbon. Each year, value of total fees would be equal to value of total rebates.
Registration Fee Transfer	A portion of annual auto registration fees would be paid through a fuel surcharge.
Purchase Incentives	Government provides a purchase incentive for the most fuel-efficient vehicle in each class at the time of sale.

(a) Carbon or CO_2 emissions are directly proportional to vehicle fuel economy.

Other Options

Other options to reduce petroleum use that were explored, but not extensively analyzed include:

- Expanded use of public transit
- Land Use Planning
- Telecommuting
- Reducing speed limits

- Voluntary Accelerated Vehicle Retirement
- Ridesharing

While these options also show potential for reducing fuel consumption, it is not well understood how effective they would be and their costs are generally site specific. However, local and regional planning agencies have analyzed these options for their particular planning areas to identify each option's ability to relieve congestion and improve system efficiency in specific transportation locations. Since the petroleum fuel displacement for these options cannot be easily extrapolated to state-wide application, the report contains only limited research and information.

Petroleum Dependence Reduction Goals and Implementation Measures

The petroleum reduction options discussed above, when combined in a cost-effective portfolio, can result in significant fuel savings and provide the basis for goals that California can achieve. Through analysis and a series of public workshops, the Energy Commission and the CARB adopted the following goals:

1) Reduce the state's energy consumption of on-road gasoline and diesel to 15 percent below the 2003 demand level by 2020.
2) Double the on-road fuel economy standards of new cars and light-trucks.
3) Increase the use of non-petroleum fuels to 20 percent of total on-road energy demand by 2020 and 30 percent by 2030.

The gasoline and diesel reduction goal for 2020 would serve as an upper limit for gasoline and diesel fuel demand for the foreseeable future. While ambitious, these goals were found to be technically feasible and cost effective with a combination of existing technologies, the use of non-petroleum fuels and further development of pre-commercial advanced technologies and fuels.

The strategy is based on implementing feasible and economic options that reduce petroleum usage and provide net benefits to society. Because some of these options compete in the same market, estimates of their individual petroleum displacements would not necessarily be additive in a portfolio. Therefore, all of the options were not used simultaneously in the process of trying to develop a fuel reduction goal.

Nearly all of the fuel efficiency options show positive direct net benefits. This analysis is sensitive to the estimated future cost of fuel and technologies, but under the cost assumptions that were made, the increased purchase price of a new, higher efficiency car or truck was typically more than offset by the lifetime fuel savings. For the fuel substitution options, a few showed positive direct net benefits, while several did not. Net benefits for these options would increase if diesel and gasoline prices are higher in the future than the levels assumed in the analysis.

The transition strategy begins in the near-term with California's gasoline and diesel demand peaking by 2010. Continuing in the mid-term, additional demand measures are implemented to reduce fuel demand to 15 percent below 2003 levels. Finally, in the long-term, the state's demand for gasoline and diesel is maintained at 15 percent below 2003 levels. The following description is an example scenario of options that could be combined to successfully achieve the petroleum reduction goal. Other combinations could emerge as technologies mature and the private sector innovates to find the optimum (lowest cost) pathway.

To implement the goals, it is helpful to view them in the logical timeframe when they can be executed: near-, mid- and long-term. Near-term is for options that could be fully implemented by 2010; mid-term is for 2010 to 2020; and long-term is for 2020 to 2030.

Near-Term
- Use more fuel efficient replacement tires with outreach campaign for proper tire inflation.
- Improve fuel economy in government fleets.
- Improve private vehicle maintenance.

Mid-Term
- Double the fuel efficiency of new light duty vehicles to 40 miles per gallon.
- Use natural gas-derived Fischer-Tropsch diesel as a 33 percent blending agent in diesel.
- Expanded use of ethanol, LNG, CNG and grid-connected hybrids among others.

Long-Term
- Introduce fuel cell light-duty vehicles in 2012, increasing to ten percent of new vehicle sales by 2020, and 20 percent by 2030.

These goals were developed to keep California's transportation sector, and the broader economy upon which it depends, robust, competitive, and environmentally sustainable. It is an aggressive petroleum reduction strategy that is technically and economically feasible using a combination of existing as well as emerging technologies.

The goals do not obviate the interim need to expand current in-state refinery and storage capacities and marine infrastructure. It would appear that the petroleum industry would have adequate time to recoup the capital investment to expand in-state facilities and realize a return on investment through the revenues generated from transportation fuels sales. Along with increased fuel supplies, actions that reduce demand growth will also be necessary to ensure that supply can meet demand.

The Linkage Between Energy and Mobility

The breadth and scope of the transportation energy challenges and issues described in this report command the attention of agencies at all levels of government, advocacy organizations, and business interests. It is important that these entities continue and expand their collaborative efforts to advance transportation technology and reduce the consumption of energy resources without sacrificing personal mobility or the satisfactory delivery of goods and services. These efforts secure and share needed expertise, funding, and physical resources to produce timely results and avoid duplication. The focus of this chapter has been the development of transportation policies that meet California's energy and air quality needs. Another important linkage in transportation is between energy and mobility.

The California Department of Transportation (Caltrans) is the lead state agency responsible for planning, designing, building, operating and maintaining California's state highway system. Transportation planning and programming in California is a complex process shared among multiple public and private entities. The process is regulated by federal and state statutes, federal and state environmental regulatory agencies, and influenced by organized interest groups and political and public will. In California, 75 percent of state and federal transportation revenues available for new capacity-increasing projects are allocated to regional transportation planning agencies. The remaining 25 percent of resources available for new capacity-increasing projects are reserved for inter-regional projects selected by Caltrans.

Caltrans also has lead responsibility to develop the California Transportation Plan, which is the state's long-range transportation policy plan that explores the social, economic, and technological trends and demographic changes anticipated over the next 20 years and their potential influence on travel behavior. The California Transportation Plan takes a balanced approach to the projected increase in demand for mobility and accessibility and seeks to guide transportation investments that benefit the state's economy, supports its communities, and safeguards the environment. Caltrans is in the process of producing the California Transportation Plan 2025 (Plan) as the update to the 1993 Plan.

Caltrans has relied on a collaboration and partnership approach in order to develop an integrated transportation system plan that promotes economic vitality and community goals among transportation providers and governmental entities, community-based organizations, urban planners, developers, social, community and emergency service providers, the environmental and business communities, permitting agencies, system users, and other affected parties. From this approach, Caltrans has developed six interdependent goals: enhance public safety and security; preserve the transportation system; improve mobility and accessibility; support the economy; enhance the environment; and reflect community values. In support of these goals a set of transportation policies have been identified.

One of the Plan's policy areas where collaboration and partnership can produce mutually beneficial results is the commitment to a clean and energy-efficient transportation system. Caltrans recognizes that California's transportation future and its energy future are linked. While it appears functionally invisible, energy is central to transportation because it basically keeps it running. By "fueling" the transportation system, tax revenues collected through energy use generates the resources needed to improve, enhance and maintain it.

Caltrans and the Energy Commission, along with the CARB and regional and local planning agencies, can partner to identify and develop transportation energy options that provide mutual benefits and meet each individual agency's mandates and goals. A set of strategy options include:

- expanding market share of cleaner vehicles and supporting fueling infrastructure.
- enhancing education, planning tools, and performance standards on energy efficiency, air quality and climate implications of transportation decision-making
- soliciting institutional support for clean, energy efficient transportation, and mainstreaming energy factors into transportation planning programming and project development.
- implementing measures to lower emissions of greenhouse gas and criteria air pollutants in transportation options.
- continuing collaboration with relevant state agencies to research and develop strategies to reduce demand for petroleum fuels, reduce emissions of greenhouse gases, and increase transportation energy efficiency.

EXAMINATION OF POTENTIAL EFFECTS OF VEHICLE EFFICIENCY IMPROVEMENTS AND NON-PETROLEUM FUELS USAGE

Public Health and Safety

The analysis conducted for the AB 2076 report shows an overall reduction in environmental impacts from vehicle efficiency improvements and non-petroleum fuels usage. By lowering petroleum fuel demand, the damage caused to public health by reducing pollution will also be reduced. This result comes from the avoidance of released pollutants from fuel production and combustion, petroleum related spills, water pollution from fuel spills and urban run off, soil contamination, and by lowering the potential impacts of climate change.

The damages to humans resulting from exposure to pollutants include adverse affects to health (morbidity), including emphysema, asthma, eye irritation, headaches, etc., and increased mortality risk.[76]

The Economy

The use of high efficiency vehicles and non-petroleum fuels will provide benefits to the economy. However, some sectors of the economy, mainly the petroleum industry, would be negatively impacted by a petroleum reduction strategy. Increased fuel efficiency would reduce the demand for refined petroleum products. In addition, decreased petroleum sector output would adversely affect upstream crude oil suppliers. While non-petroleum fuels will replace conventional fuels, there will need to be an industry that produces and provides these fuels to the market. The petroleum industry is in a favorable position to make up for its loss in the transportation fuels market by transitioning to be a competitor in the new non-petroleum fuels market.

On the other hand, California's economy would benefit from savings realized from the reduction of health related costs from avoided pollution. In addition, consumers and many businesses in the state will benefit if the implementation of petroleum reduction goals results in lower fuel expenditures. Money freed from fuel expenditure requirements would be spent on other products such as food and apparel.[77]

Government revenues would also be impacted by reduced demand for petroleum. Savings to the government could be realized from avoided clean up costs of petroleum fuels related spills and contamination and other forms of pollution. However, potentially more significant is the loss of tax revenue due to reduced collection of excise taxes on petroleum fuels. Even if petroleum use is simply replaced by alternative fuels, tax revenues may be reduced since tax rates on non-petroleum fuels are in some cases, and may continue to be, lower than for petroleum-based fuels.

Resources

The potential impacts on California's resources as a result of reduced petroleum use have not been extensively examined. The potential impact on natural gas supply caused by an increase in natural gas vehicles could affect already tight supplies of this increasingly important fuel. Natural gas is also a feedstock for other fuels, including Fischer-Tropsch diesel, other gas-to-liquids fuels, and hydrogen, so gas markets may be impacted by the use of these fuels. These possibilities warrant monitoring and further evaluation.

Environment

Reducing petroleum consumption has the potential to provide air quality benefits, whether the reduction comes from increased fuel efficiency or from fuel substitution. While improved fuel efficiency does not directly reduce criteria pollutants, a beneficial impact is realized because of reductions in upstream emissions. For example, reduced petroleum consumption results in lower emissions at refineries, fewer trips from tanker trucks, trains, and ships transporting fuel, and lower evaporative emissions from refueling.

Substituting petroleum fuels with alternative fuels can have a beneficial impact on tailpipe emissions. However, life cycle emissions resulting from the use of alternative fuels and technologies depend on many factors, including vehicle emission control technology, feedstock type, and fuel production process. For example, the electricity used to recharge an electric vehicle could come from sources that produce no emissions (i.e., hydroelectric, solar) or substantial emissions (i.e., older gas-fired plant). This is also true for other fuels, such as hydrogen and ethanol.

The greatest potential for reducing life-cycle emissions from a given vehicle comes from battery electric and direct hydrogen fuel cell technologies, since they produce no tailpipe or evaporative emissions. Ultimately, the lowest life cycle emissions result from combining zero emission technologies and a renewable fuel (i.e., solar, wind, etc.). While this environmentally preferred scenario is available today, high costs will continue to limit its widespread acceptance in the near term.

Criteria pollutants, including carbon monoxide, volatile organic compounds, oxides of nitrogen and others can also be reduced from lowering petroleum demand. According to the analysis for the AB 2076 report, reducing a gallon of gasoline consumption results in the reduction of approximately 1.1 grams of criteria pollutants from both the vehicle and fuel cycle.[78]

The use of non-petroleum fuels and more fuel efficient vehicles also have the potential to reduce greenhouse gases. Although the potential impacts of climate change are wide-ranging, California has reason to be particularly concerned about coastal impacts, due to rising sea levels and altered precipitation patterns that could change the timing and relative amounts of rain and snowfall in the Sierra Nevada Mountains.[79] Reducing gasoline consumption by one gallon results in the reduction of approximately 11 kilograms of global greenhouse gas emissions, taking into account both vehicle and fuel cycles.[80]

Energy Security

While debate continues as to the sufficiency of world oil supplies in the longer term, experts conclude that world oil supplies will gradually decline, with domestic supplies decreasing long before those in the Middle East. In addition to the likelihood of higher oil prices, this will result in even greater reliance on foreign sources of petroleum, an energy security risk for California and also for the nation as a whole.[81]

Lowering the state's demand for petroleum offers potentially significant energy security benefits. The use of non-petroleum fuels would diversify our transportation fuel mix, leaving the state less vulnerable to external petroleum supply shocks.

NEED FOR CONTINUED ANALYSIS AND RESEARCH, DEVELOPMENT AND DEMONSTRATION

While the AB 2076 work suggests that petroleum use can be reduced significantly by strategies that provide net benefits to the state, the analysis is subject to many uncertainties. Such uncertainties include (among others) the costs and effectiveness of new vehicle technologies, the value to the state of reduced environmental damages, particularly reduced greenhouse gas emissions, the impact of higher fuel efficiency on vehicle safety and consumer choice, and the impact of higher fuel efficiency on driving patterns. Further investigation of these uncertainties must continue to ensure that California makes the transition to a more efficient, environmentally sound and diverse transportation energy system in the most cost-effective manner possible.

The Energy Commission also believes it is critical to invest in transportation technology advancement. Investments in technology to reduce future demand for fuels can produce overall net economic, environmental, and energy security benefits. While commercially available technologies exist to help California attain much of the proposed performance and cost improvements, significant additional work is needed with emerging transportation technology options that can only be achieved through additional RD&D activities.

Technologies selected for evaluation under the AB 2076 report include promising options to improve fuel efficiency and increase the use of non-petroleum fuels. These options can benefit from additional investment in RD&D. Some have found successful use in niche applications, such as compressed natural gas and liquefied natural gas in bus and truck fleets or other high usage applications. Hybrid electric technologies appear to be emerging rapidly, spurred by initial consumer interest in a limited number of models offered by manufacturers. Others, such as hydrogen fuel cells, require significant development and performance breakthroughs before a commercial opportunity can be assured. Nevertheless, if RD&D goals being pursued for these options are successfully achieved, these longer term technologies can have widespread commercial application.

Technical and market barriers related to these technology options should be priorities for consideration in state RD&D activities. Although, these options are at different levels of maturity, the Energy Commission clearly has an opportunity to play a lead role in the resolution of infrastructure barriers facing non-petroleum fuels. The Energy Commission can coordinate with government fleets to acquire and demonstrate non-petroleum fueled vehicles and advanced technologies with improved efficiency. Analytically, the Energy Commission can evaluate market barriers faced by manufacturers who may be reluctant to invest in greater vehicle efficiency and support the study of consumer choice and behavior to better focus information campaigns for more efficient vehicles.

According to the AB 2076 analysis, improving new vehicle fuel economy produces both the largest net benefits and the largest displacement of petroleum fuel. While important fuel economy gains can be achieved with application of existing technologies, the recommended doubling of new vehicle fuel economy, for example, requires successful attainment of various RD&D goals. The likely success of these options will be greatly improved through research and analysis on a variety of factors that influence manufacturer investment decisions on fuel efficiency, performance, design impacts on safety, and consumer choice.

Continuing RD&D for other fuel substitution options that were not projected to provide positive direct net benefits in the AB 2076 analysis may improve their standing compared to existing petroleum fuel technologies and lead to increased use in niche applications. RD&D activities for the fuel substitution options include work to improve end-use performance, as well as to improve fuel production performance and infrastructure deployment.

Public Interest RD&D

Industry interests can conflict with public welfare, such as in the case of vehicle efficiency improvement. The automobile industry has claimed that investing limited RD&D dollars to develop new technologies that may improve efficiency will not be profitable if high efficiency vehicles remain less popular with car buyers. Within the petroleum industry, supporting RD&D for higher vehicle efficiency results in lower product sales and becomes a powerful financial and strategic disincentive. These and other examples of private sector reluctance to pursue public benefits underscore the need for public resources to support targeted transportation RD&D. Public interest RD&D for transportation should focus on areas the private sector perceives to produce insufficient financial gain. These areas include:

- Improving energy diversity and energy security,
- Improving engine and overall vehicle fuel efficiency,
- Reducing emissions of criteria pollutants beyond regulated levels,
- Developing fuels that are derived from renewable resources,
- Developing low carbon fuels and technologies with low life cycle emissions of greenhouse gases.

In undertaking public interest RD&D, the state should leverage its resources and pursue opportunities that will provide RD&D advancements to multiple energy sectors whenever possible. The involvement of the Energy Commission in fuel cell RD&D is such an example. Because polymer electrolyte membrane (PEM) fuel cell technology and many of the support systems are identical for stationary and transportation applications, opportunities exist for collaboration in RD&D.

Collaboration has been established between the California Fuel Cell Partnership, a public/private effort to commercialize fuel cell vehicles, and the Energy Commission's Public Interest Energy Research (PIER) Program. The participation in the California Fuel Cell Partnership by both the Energy Commission's Transportation Energy Division and the PIER Program provides excellent opportunities to leverage resources with other government and industry partners to benefit both transportation and stationary fuel cell advancements.

The fuel cell activities of the PIER Program currently focus on higher temperature technologies, such as solid oxide fuel cells. This is due in part because the development of lower temperature PEM technology is driven by large research budgets provided by the U.S. DOE, U.S. Department of Transportation, and the transportation industry. As a result, PIER Program participation has typically been limited to monitoring technology status.

The PIER Program investment targets results that might have an impact on fuel cell development similar to those achieved by other members on PEM research. Work that needs to be addressed includes improving fuel cell system efficiency, reliability and lowering production costs. Information gathered will also help advance fuel cell technology by identifying issues associated with codes and standards, safety and infrastructure development.

Furthermore, the RD&D on fuel cells will include work on hydrogen, which can open paths towards increasing energy diversity by utilizing domestic fossil and renewable resources. Because of the substantial investments required to research and develop hydrogen infrastructure, efforts undertaken collaboratively increase the chances of widespread hydrogen use.

Investment is also needed to develop fueling infrastructure for non-petroleum fuels where industry investment is perceived to be too risky or return on investment is insufficient. Whereas today's petroleum industry includes several very large, well capitalized companies with multi-million dollar research and development (R&D) budgets, industry leaders developing non-petroleum transportation fuels often lack the resources required to develop fueling infrastructure. Where this occurs, government RD&D support and resources is needed.

An example of one area of need within transportation RD&D is the advancement of fueling infrastructure, particularly for emerging fuels such as hydrogen. As technical barriers and cost reductions are being addressed for hydrogen fuel cell technology and related integration with vehicle systems, an equally important research and development arena involves issues of production and distribution of hydrogen, resource feedstocks, and possible integration of mobile fuel cells with stationary energy systems. These latter subjects, bundled under the general heading of hydrogen infrastructure and pathways, focus on making the possible transition from conventional petroleum fuel technologies to a hydrogen-based system.

The attractiveness of hydrogen as a source of energy is linked to its fuel cycle benefits. However, the existing transportation marketplace does not favor products with this emphasis. Thus, potential market success for hydrogen fuel cell vehicles may depend upon a new consumer perspective. This perspective would recognize that the choice of hydrogen feedstock, producing, and delivering hydrogen, and fuel cell multi-use are also valued attributes because these elements are part of the fuel cycle.

R&D on hydrogen infrastructure and pathways and pilot demonstrations of leading candidate systems are important steps in the successful deployment of fuel cell technology. Determining the preferred mix of attributes that lead to the lowest direct consumer expense (i.e., lowest cost vehicle and operating cost combination) or best net benefit (includes societal and energy security benefits) will be necessary to commercialize hydrogen fuel cell vehicles. Other fuels, including LNG, LPG, ethanol and others, stand to benefit from RD&D spending in an effort to explore and develop ways to reduce infrastructure capital requirements, and maintenance and operating expenses.

Transportation RD&D Collaboration

Reducing the ill effects of the state's petroleum dependence depends on the advancement and use of new transportation technologies and fuels. Also, improving overall efficiency of the transportation system and operations could provide additional energy savings. Although our primary modes of mobility, the personal automobile and other on-road vehicles, have steadily advanced for the past century, a doubling of fleet fuel economy and near zero emission performance remain feasible and cost-effective. The marriage of more efficient combustion technologies with electric drive technologies in hybrid electric vehicles is a clear example of the significant energy and environmental improvements that can come from technology advancement.

If ongoing work to commercialize hydrogen fuel cells for stationary and mobile applications proves to be successful, our future vehicles can serve as a multi-purpose system for mobility and power generation but without the adverse environmental impacts of fossil fuel production and use. Investment and collaboration in the development of new transportation energy technologies and fuels are inherent ingredients for solving our transportation energy problems.

Commercial demonstrations are also important activities to bring technologies to the marketplace. Typically, commercial demonstrations are in captive fleets where vehicles can be monitored and tested under controlled conditions. These types of demonstrations focus on the vehicle's operational durability in commercial settings and are the last phase before market introduction.

The Energy Commission currently supports transportation advancement with numerous organizations that merit continuation. The Energy Commission provides technical review services for CALSTART, the U. S. DOE, the South Coast Air Quality Management District, the Natural Gas Vehicle Partnership, the Mobile Source Air Pollution Reduction Review Committee, the Interstate Clean Transportation Corridor, and the Innovative Clean Air Technology Program and the Climate Change Emissions Regulations Program of the CARB. The Energy Commission also supports the activities of the California Fuel Cell Partnership and the U.S. DOE Clean Cities Program with direct co-funding, project sponsorship, and project administration.

The Energy Commission has collaborated with Caltrans over the years in planning, funding and developing alternative technologies that can displace gasoline and diesel vehicles with cleaner and more energy efficient vehicles. In addition, the Energy Commission and Caltrans have collaborated in funding and developing innovative methods that can incorporate energy considerations into the transportation planning process. Energy Commission and Caltrans collaboration have included the installation of LPG vehicle fueling stations, demonstration of Fischer-Tropsch diesel fuel in heavy-duty vehicles, participation in Caltrans' "Greening the Fleet" initiative, "Driving Green" Task Force and the California Transportation Plan 2025, and coordination on the Joint Agency Climate Team effort to develop initiatives on climate change.

While the Energy Commission has from time to time retained the research services of the Institute of Transportation Studies at the University of California, Davis and the College of engineering, Center for Environmental Research and Technology (CE-CERT) at the University of California, Riverside, a stronger collaboration to support the research activities of these and other academic institutions would be beneficial. The Energy Commission should explore and develop opportunities to co-fund research on consumer choice, energy demand reduction concepts, land use planning and transportation implications, the valuation of externalities in using transportation energy, and more efficient use of transportation technologies.

California's Transportation RD&D Background

Historically, the Energy Commission has provided resources to advance transportation RD&D, including support for the development of methanol-fueled vehicles, ethanol production plants and various programs that supported a wide variety of alternative fuel vehicle projects. In particular, the Transportation Energy Technology Advancement Program, through annual competitive solicitations, provided several million dollars match share to a variety of advanced transportation projects in the 1990s.

Recent transportation RD&D at the Energy Commission includes the following activities:

- The Energy Commission is supporting the development of small-scale liquefied natural gas production facilities for vehicle use. The goal of the projects funded to date is to demonstrate a variety of technologies and achieve cost targets.

- The Energy Commission is one of the partners supporting R&D for natural gas vehicle engines through the Next Generation Natural Gas Vehicle Program. This effort is working to develop advanced, commercially viable, medium- and heavy-duty natural gas vehicles that are energy efficient and ultra low emitting.

- The Energy Commission is working with federal agencies and programs on transportation issues, such as the U.S. DOE State Energy Programs grants and the Clean Cities program aimed at supporting a variety of clean, alternative fuel vehicle programs.

- The state is leveraging its resources by working with the U.S. DOE and industry on programs such as the FreedomCAR Initiative. This multi-year effort will advance fuel cell vehicle technologies and other efficient vehicle designs.

- The Energy Commission and the CARB are participants of the California Fuel Cell Partnership. The California Fuel Cell Partnership is a public/private endeavor working to help commercialize fuel cell vehicles, with ongoing demonstrations of both passenger vehicles and transit buses that operate on fuel cells. Furthermore, the California Fuel Cell Partnership is developing and demonstrating hydrogen and methanol fueling infrastructure critical for the use of fuel cell vehicles.

For approximately twenty years, the Energy Commission has primarily relied upon Petroleum Violation Escrow Account (PVEA) funds distributed by the federal government for transportation program expenditures aimed at reducing the demand for petroleum-based fuels. These funds have been used for both R&D efforts, as well as demonstrations of alternative fuel vehicles and fueling infrastructure. PVEA funds, however, are now largely exhausted and the resulting inconsistent mix and magnitude of current funding sources threaten the continuity of the state's transportation energy programs. Despite the importance of the Energy Commission's programs, funding levels for transportation energy programs has steadily declined and California is now losing its traditional leadership role in this arena.

While its contribution to RD&D has been comparatively modest compared with industry and the federal government, the state is in a unique position to focus resources toward specific programs and transportation systems that will provide the greatest internal benefits. Furthermore, California's role as the largest car and truck market in the country allows it to play a critical role in shaping transportation energy use.

It is paramount that the Energy Commission establishes a consistent and determinate funding source to make RD&D investments in transportation energy. Making direct monetary contributions to these development activities ensures that the state can capture the benefits of reduced reliance on petroleum fuels and greater transportation energy efficiency. Such efforts will influence industry investment decisions and shape the future of transportation in California. Ultimately, the development of advanced transportation technologies plays a vital role in a thriving economy and is inherently linked with conditions that protect public health and preserve the state's environment and natural resources.

CHAPTER 8: FINDINGS AND RECOMMENDATIONS TO STRENGTHEN THE TRANSPORTATION ENERGY INFRASTRUCTURE

In the energy assessment of California's transportation energy sector, three major issues have been identified. They are:

1. Currently, California continues to be vulnerable to gasoline and diesel fuel price spikes that result from unanticipated supply disruptions.

2. In the near term, California will experience higher and more volatile fuel prices if the transportation fuel industry cannot develop additional gasoline and diesel fuel to meet California's growing demand.

3. In the longer term, California needs to transition to an efficient, environmentally sound and diverse transportation system that reduces our dependence on petroleum and contribution to greenhouse gas emissions.

FUEL PRICE VOLATILITY

California is susceptible to price spikes as a result of unanticipated disruption in supplies due to California's petroleum industry's relative isolation and unique gasoline specifications. To remedy this situation, it is the state's marine infrastructure that is the primary entry point for the needed fuel supply and storage that can help mitigate or dampen price spikes. The state has a role to ensure that unconstrained movement of imported gasoline and diesel supplies is adequate to meet the state's transportation fuel demands. To address California's current fuel price volatility issue, the Energy Commission recommends that:

- The Energy Commission should undertake a comprehensive evaluation of California's infrastructure needed to handle future crude oil and petroleum product imports, in consultation with the following agencies – State Lands Commission, Ports of Los Angeles and Long Beach, Coastal Commission, and San Francisco Bay Conservation and Development Commission.

- The Governor and legislature should identify a state licensing authority for petroleum infrastructure facilities.

INSUFFICIENT FUEL SUPPLY TO MEET NEAR-TERM DEMAND GROWTH

In the near-term, California's growing demand for transportation fuels will need to be met by significant increased levels of imports from foreign sources. If California's fuel demand cannot be met, California will experience higher and more volatile fuel prices. At this time, there is a lack of information to determine if sufficient supply additions are available or in planning. The Energy Commission recommends that:

- The Energy Commission should continue to work with the petroleum industry to collect information on future expansion and construction plans for in-state refining capacity and importation of crude oil, blend stocks and finished products to assess future supply adequacy, as well as constraints to expansion that might adversely impact the delivery of future transportation fuel supplies.

In addition, the Energy Commission needs to determine the possible impacts of several ongoing legislative and regulatory proceedings on the quantity, price and quality of gasoline and diesel fuel needed to meet demand. These proceedings are:

- Federal waiver to allow the use of non-oxygenated gasoline in certain areas of California. Without the waiver, California would need to use ethanol to comply with federal law, which would also impact supply of gasoline.

- Pending legislation in Congress to modify the federal Energy Policy Act. The Energy Policy Act of 2003 is currently moving through Congress. If enacted, the Energy Policy Act of 2003 would significantly alter federal requirements affecting the use of ethanol in California. Use of ethanol as a gasoline additive would no longer be required to meet federal air quality regulations. The extent of ethanol use in California contributing to meeting the national renewable fuels standard would be left to decision-making by fuel marketers.

- Reduced sulfur levels in gasoline and diesel fuels throughout the U.S. Adopted federal and state regulations requiring reduced sulfur levels in gasoline and diesel fuels compel the refining industry to make investments greater than $5 billion for gasoline alone. Refiners will need to make modifications to meet the new gasoline and diesel fuel specifications. In addition, as other states begin to use these lower sulfur fuels, California may be affected in the price it pays and availability of fuel and blending components from other states.

To address any actions that come from these related proceedings, the Energy Commission recommends that:

- California should continue to pursue a waiver from U.S. Environmental Protection Agency's gasoline oxygenate requirements.

- The Energy Commission should continue to monitor the pending federal Energy Policy Act legislation and its impacts on California's transportation fuel price, supply and infrastructure.

- The Energy Commission should continue to monitor the progress of refineries to meet the California Air Resources Board low sulfur diesel fuel regulation, as well as the progress of other states' implementation efforts.

Lastly, it is important that the world oil market can provide the necessary fuels in the interim, as California becomes more dependent on foreign sources of petroleum. Therefore, the Energy Commission recommends that:

- The Energy Commission should more closely monitor world oil supply markets to provide advance planning opportunity to respond to significant changes in world oil production. Areas to monitor include: production profiles, reserves to production ratios, industry and related financial markets, global oil substitution and demand reducing trends, OPEC market share trends and crude oil price projections.

TRANSITION TO AN EFFICIENT, ENVIRONMENTALLY SOUND AND DIVERSE TRANSPORTATION ENERGY SYSTEM

California's dependence on petroleum to meet its transportation energy needs will, in the long term, produce negative impacts. These negative impacts have economic, environmental and social costs that will reduce our competitive advantage, quality of life and economic well-being. California can effectively transition from petroleum dependence to an efficient, environmentally sound and diverse transportation energy system. The Energy Commission recommends that:

- The Governor and legislature should adopt the recommended statewide goal of reducing demand for on-road gasoline and diesel to 15 percent below the 2003 demand level by 2020 and maintain that level for the foreseeable future.

- The Governor and legislature should work with the California Congressional delegation and other states and organizations to establish national fuel economy standards that double the fuel efficiency of new cars, light trucks, and sport utility vehicles.

- The Governor and legislature should establish a goal to increase the use of non-petroleum fuels to 20 percent of on-road fuel consumption by 2020 and 30 percent by 2030.

There is an important area that can provide support to meeting the long-term goal. Research, development and demonstration and analytical activities are necessary and critical components to enable strategy options to compete in the marketplace. The Energy Commission recommends that:

- The Energy Commission should establish a working group of industry, environmental, and academic stakeholders to develop specific strategies to support research, development, and demonstration consistent with the recommendations adopted in the ***Reducing California's Petroleum Dependence Report,*** which was in response to mandates in AB 2076.

- The Energy Commission should work with the California Air Resources Board to continue to analyze the strategies identified in the AB 2076 report to improve its understanding of the costs and effectiveness of new vehicle technologies, the value to the state of reduced environmental damages, and the impact of higher fuel efficiency on vehicle safety, consumer choices, and driving patterns.

- The Energy Commission should work with the California Department of Transportation to develop and disseminate information on transportation energy issues and evaluate the costs and benefits of fuel demand reduction options and deployment strategies, including: land use planning concepts, public transportation, and incorporating energy considerations in transportation planning and decisionmaking.

- The Energy Commission, working through public/private collaborations and partnerships, should pursue basic transportation energy research, hardware development, and infrastructure deployment.

ACRONYMS

AB 2076	Assembly Bill 2076 (Chapter 936, Statutes of 2000)
ACEEE	American Council for an Energy Efficient Economy
APU	Auxiliary power unit
B100	A transportation fuel that is 100 percent biodiesel.
B2	A transportation fuel that is two percent bidodiesel with conventional petroleum diesel
B20	A mixture of 20 percent biodiesel and 80 percent diesel fuel.
Bbl	Barrel
Btus	British thermal units
CAFE	Corporate average fuel economy
Caltrans	California Department of Transportation
CALSTART	A non-profit organization that works with the public and private sectors to develop advanced transportation technologies.
CARB	California Air Resources Board
CARB Diesel	Diesel fuel that meets specifications set by the California Air Resources Board
CEQA	California Environmental Quality Act
CNG	Compressed natural gas
CO	Carbon monoxide (CO_2 – carbon dioxide)
E85	Alcohol fuel blend containing of 85 percent ethanol and 15 percent gasoline
EEA	Energy and Environmental Analysis Inc.
EPACT	Energy Policy Act of 1992
EV	Electric vehicle
FCV	Fuel cell vehicle. A fuel cell is a device that through an electrochemical reaction converts fuel (hydrogen and oxygen) into electricity.
FFV	Flexible fuel vehicle
FreedomCAR	Cooperative Automotive Research Initiative sponsored by the U.S. Department of Energy
GTL	Gas-to-liquid
H_2	Hydrogen
HDVs	Heavy-duty vehicles (generally defined as those vehicles that weigh over 10,000 pounds, includes medium and heavy-duty trucks and buses, a much smaller number account for passenger transport).
Hybrids	Gasoline-electric hybrid vehicles
ICE	Internal combustion engine
Jones Act	Fleets loaded at a U.S. port that sail to another U.S. destination must be shipped on a domestic flag vessel in accordance with federal law.
LDV	Light-duty vehicle
LNG	Liquefied natural gas

LPG	Liquefied petroleum gas
M100	100 percent methanol
M85	Alcohol fuel blend containing of 85 percent methanol and 15 percent gasoline that can be used in specially designed flexible fuel vehicles.
MBbl	Thousand barrel
Mbd	Million barrels per day
MDV	Medium-duty vehicle
MMBbl	Million barrel
mpg	Miles per gallon
MTBE	Methyl tertiary-butyl ether (an oxygenate additive in gasoline)
NEV	Neighborhood electric vehicle
NGV	Natural gas vehicle
NHTSA	National Highway Traffic Safety Administration
NO_X	Nitrogen oxide
NRC	National Research Council
OPEC	Organization of Petroleum Exporting Countries (An international organization primarily concerned with coordinating the crude-oil policies of its member states.)
OPS	Department of Transportation's Office of Pipeline Safety
PEM	polymer electrolyte membrane
PIER	Public Interest Energy Research program
Plan	Transportation Plan 2025 (a report led by Caltrans, California's long-range transportation policy plan)
ppm	Parts per million
PRC	Public Resources Code
PSA	Permit Streamlining Act
Psi	Pounds per square inch
PVEA	Petroleum Violation Escrow Account
R&D	Research and development
RD&D	Research, development, and demonstration
RFS	Renewable Fuel Standard
SFM	Office of the State Fire Marshal
SFR	Strategic Fuels Reserve found in Assembly Bill 2076
SUV	Sport utility vehicles
TBD	Thousand barrel per day
TETAP	Transportation Energy Technology Advancement Program
U.S.	United States
U.S. DOE	United States Department of Energy
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VMT	Vehicle miles traveled
VOC	Volatile organic compounds
ZEV	Zero emission vehicle

ENDNOTES

[1] California Energy Commission*, Reducing California's Petroleum Dependence*, Joint Agency Report, July 2003 (Publication # P600-03-005F).
[2] Note that fuel cost per mile is equal to the price per unit of fuel divided by fuel efficiency (miles traveled per unit of fuel).
[3] Memo from California Energy Commission Staff, Chris Kavalec, 7/18/03. Note business establishments includes government fleets in the calculations.
[4] Transportation Energy Consumption Estimates, 1960-2000, California, www.eia.doe.gov/emeu/states.
[5] Based upon data from the Energy Information Administration, U.S. Department of Energy, *Fuel Oil and Kerosene Sales 1998*, Tables 23 and 24, Washington, D.C., August 1999.
[6] This assumption is consistent with the most recent Federal Aviation Administration forecast (source: *FAA Aerospace Forecast, Fiscal Years 2003-2014*, March 2003).
[7] The $25 per barrel oil price projection is a staff estimate for the average U.S. refiner acquisition cost of crude oil (in 2003 dollars) based on analysis of historical oil prices and current market trends, surveys of other organizations' oil price forecasts, testimony received at California Energy Commission workshops, and assessment of OPEC oil marketing strategies.
[8] http://www.energy.ca.gov/oil/statistics/crude_oil_receipts.html.
[9] Joseph Leto, Energy Analysts International, Presentation: "U.S. West Coast Petroleum Supply, Logistics and Economic Outlook" at California Energy Commission, Integrated Energy Policy Report -Transportation Fuels Workshop, July 11, 2003, Docket #02-IEP-01, ***(available online http://www.energy.ca.gov/energypolicy/index.html)***.
[10] California Energy Commission, Petroleum Industry Information Reporting Act (PIIRA) Database.
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